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Remediation Objectives and Approaches

INTRODUCTION

The record of decision (ROD) for cleanup of the Bunker Hill Mining and Metallurgical Complex Superfund Facility Operable Unit 3 (OU-3) (EPA 2002) represents the next step in a long and contentious path for all concerned with human health and the environment in the Silver Valley of northern Idaho, Lake Coeur d'Alene, and the Spokane River down to Upriver Dam. "The Facility includes mining-contaminated areas in the Coeur d'Alene River corridor, adjacent floodplain, downstream water bodies, tributaries, and fill areas, as well as the 21-square-mile Bunker Hill 'box' located in the area surrounding the historic smelting operations" (EPA 2002, Part 1, p. 1). The facility was listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List in 1983. It took almost 10 years for the U.S. Environmental Protection Agency (EPA) to issue RODs for remediation of the area considered to be the major source of risk to human health and the environment—a 21-square-mile area (the "box") roughly encompassing the Interstate 90 corridor from Pinehurst to Kellogg, Idaho. RODs were signed for the populated areas of the Bunker Hill box (OU-1) and the nonpopulated areas of the box (OU-2) in 1991 and 1992, respectively. In 1998, EPA extended Superfund activities outside of the box to OU-3, and the ROD for this operable unit was issued in 2002.

The Bunker Hill box has been undergoing active remediation for several years to protect residents in the area, especially children, from excessive exposure to lead and to control transport of lead and zinc downriver. Major cleanup activities by mining companies, the state of Idaho, and EPA have included regrading and/or removing mine tailings and sediment from many areas in the floodplain of the Coeur d'Alene River; constructing a central impoundment area (CIA) for the storage and isolation of mine tailings and contaminated sediments; operating the central (water) treatment plant (CTP) for treatment of acid mine drainage; remediating contaminated areas in the former smelter complex; and removing contaminated soil from yards and public areas to lower the exposure of children to lead contamination. The ROD for OU-3 was developed through the remedial investigation/feasibility study (RI/FS) process and is intended to interact with and take advantage of remedial actions taken under the RODs for OU-1 and OU-2. In essence, the ROD for OU-3 was the next step in addressing basin-wide human health and environmental issues caused by past mining operations.

As provided in the statement of task (see Appendix A), the committee is charged with assessing the scientific and technical aspects of EPA's remedial objectives and approaches set forth to address environmental contamination in OU-3 of the Coeur d'Alene River basin Superfund site.

REMEDIATION OBJECTIVES AND INCORPORATION OF CLEANUP GOALS

One of the purposes of the feasibility study (FS) (URS Greiner, Inc. and CH2M Hill 2001a), which was prepared under contract for EPA, was to develop remedial action objectives (RAOs). The RAOs are long-term goals for cleanup and recovery from historic effects of mining in the Coeur d'Alene River basin and focus on protecting human health and ecologic receptors (for example, fish and wildlife). They are intended to provide a general description of the goals of the overall cleanup (EPA 2002, p. 8-1). These objectives, described below, are inclusive of the expected sources of contaminants and routes of exposure to humans and ecologic receptors.

Human Health

RAOs for protection of human health are designed primarily to reduce human exposure to lead-contaminated soils, sediments, and house dust to protect children; reduce human exposure to contaminated soils and sediments to lower the risks of cancer; and reduce ingestion of groundwater and surface waters from private, unregulated sources that do not meet drinking water standards (EPA 2002, p. 8-1). RAOs for protecting human health that are specific to environmental media (for example, water and soil) are described in Table 8-1 (EPA 2002, Table 8.1-1) and applicable and

TABLE 8-1 RAOs for Protection of Human Health

Environmental Media	RAOs
Soils, sediments, and source materials	Reduce mechanical transportation of soil and sediments containing unacceptable levels of contaminants into residential areas and structures. Reduce human exposure to soils, including residential garden soils and sediments that have concentrations of contaminants of concern greater than selected risk-based levels for soil
House dust	Reduce human exposure to lead in house dust via tracking from areas outside the home and air pathways, exceeding health risk goals
Groundwater and surface water as drinking water	Reduce ingestion by humans of groundwater or surface water withdrawn or diverted from a private, unregulated source, used as drinking water, and containing contaminants of concern exceeding drinking water standards and risk-based levels for drinking water
Aquatic food sources	Reduce human exposure to unacceptable levels of contaminats of concern via ingestion of aquatic food sources (for example, fish and water potatoes)

SOURCE: EPA 2002.

relevant or appropriate requirements (ARARs) for drinking water are described in Table 8-2 (EPA 2002, Table 8.1-2). Cleanup actions for protection of human health were "designed to address both current and potential future risks, and . . . to limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a 10 μg/dL [microgram per deciliter] blood lead level" (EPA 2004a, p. 13).

Ecologic Receptors

The RAOs for ecologic protection are long-term goals used to develop ecologic remediation alternatives to protect ecologic receptors. RAOs for the protection of ecologic receptors and systems are described in Table 8-3 (EPA 2002, p. 8.6).

DESCRIPTION AND COMPARISON OF REMEDIAL ALTERNATIVES

The Superfund process requires that alternative approaches be developed to address risks to human health and the environment caused by sources of contamination and that the relative advantages of each alterna-

TABLE 8-2 ARARs for Drinking Water

Metal	MCL[a] or TT[b], μg/L
Arsenic	10
Cadmium	5
Lead	TT[c] Action Level = 15

[a]Maximum contaminant level (MCL) is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCL goals as feasible using the best available treatment technology and taking cost into consideration.
[b]Treatment technique (TT) is a required process intended to reduce the level of a contaminant in drinking water.
[c]Lead is regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps.
SOURCE: EPA 2002.

tive be compared and documented. For OU-3 in the Coeur d'Alene River basin, alternatives were extensively investigated and described in the FS.

The process of identifying and developing potentially applicable cleanup methods is complex. This effort resulted in a massive, multivolume set of documents setting forth the details of each remedial alternative considered. Remedial alternatives focused on four separate but interrelated areas of risk (EPA 2002, p. 9-1):

- Protection of human health in the populated and community areas of the upper basin and lower basin
- Protection of ecologic receptors in the upper basin and lower basin
- Protection and restoration of Lake Coeur d'Alene
- Protection of human health and ecologic receptors for the Spokane River from the Idaho-Washington State line to Upriver Dam in eastern Washington

Remedial alternatives are analyzed and described only to the level needed to support development of a proposed plan for cleanup, which is then expanded after the selection of alternatives in the ROD. In this regard, EPA states: "Consistent with the NCP, the remedial alternatives have been developed to a planning level of detail, not a design level of detail. All remedial actions would require a site-specific remedial design that may include additional data collection to further define the problem and refine the action." (EPA 2001a, p. 6-1).

Consistent with the NCP, each set of alternatives must include a "no-action" alternative to provide a baseline or "do-nothing" scenario for com-

TABLE 8-3 RAOs for Protection of Ecologic Receptors

Subject	RAO
Ecosystem and physical structure and function	Remediate soil, sediment, and water quality and mitigate mining impacts in habitat areas to be capable of supporting a functional ecosystem for the aquatic and terrestrial plant and animal populations in the Coeur d'Alene River basin; maintain (or provide) soil, sediment, and water quality and mitigate mining impacts in habitat areas to be supportive of individuals of special-status biota that are protected under the Endangered Species Act and the Migratory Bird Treaty Act
Soil, sediment, and source materials	Prevent ingestion of arsenic, cadmium, copper, lead, mercury, silver, and zinc by ecologic receptors at concentrations that result in unacceptable risks; reduce loadings of cadmium, copper, lead, and zinc from soils and sediments to surface water so that loadings do not cause exceedances of potential surface water-quality ARARs; prevent transport of cadmium, copper, lead, and zinc from soils and sediments to groundwater at concentrations that exceed potential surface water-quality ARARs
Mine water, including adits, seeps, springs, and leachate	Prevent dermal contact with arsenic, cadmium, copper, lead, mercury, silver, and zinc by ecologic receptors at concentrations that result in unacceptable risks; prevent discharge of cadmium, copper, lead, and zinc in mine water, including adits, seeps, springs, and leachate to surface water at concentrations that exceed potential surface water-quality ARARs
Surface water	Prevent ingestion of cadmium, copper, lead, and zinc by ecologic receptors at concentrations that exceed potential surface water-quality ARARs; prevent dermal contact with cadmium, copper, lead, and zinc by ecologic receptors at concentrations that exceed potential surface water-quality ARARs
Groundwater	Prevent discharge of groundwater to surface water at concentrations of cadmium, copper, lead, and zinc that exceed potential surface water-quality ARARs

SOURCE: EPA 2002.

parison with alternative remedial actions. Consideration of a "no-action" alternative is necessary to ensure that there is a benefit to proposed remedial actions and that remedial actions "do no harm."

Alternatives for the protection of human health that address exposure pathways through soil, house dust, drinking water, and aquatic food sources are summarized in Box 8-1. Alternatives for the protection of the environment that mitigate ecologic risks are summarized in Box 8-2. A summary of the projected costs estimated for the various cleanup alternatives is reproduced in Table 8-4 (EPA 2001a).

BOX 8-1 Alternatives for Human Health Protection

Human health alternatives were developed to address the primary exposure pathways through soil, house dust, drinking water, and aquatic food sources. In addition to limiting direct exposure, soils remediation alternatives also address the issue of controlling the risks from eating homegrown vegetables. These alternatives are further discussed in the ROD (EPA 2002, pp. 9-2 to 9-7).

Soils

The remedial alternatives considered for controlling human health risks from lead-contaminated soils include the following: S1, no action; S2, information and intervention; S3, information and intervention and access modifications; S4, information and intervention and partial removal and barriers; and S5, information and intervention and complete removal.

All alternatives for protecting children from exposure to lead in contaminated soils involve public information and intervention, except for the no-action alternative. Other more aggressive alternatives require access modifications such as construction of fences and barriers. More complete cleanup would require either partial or complete removal of soils in residential yards and garden areas to depths of 1-4 feet and replacement with clean fill. Alternatives S4 and S5 also call for pressure washing structure exteriors when appropriate to reduce the risk of recontamination from lead-based paint. S5, the complete removal alternative, is not envisioned for recreational areas.

Drinking Water

The alternatives considered to limit human exposure to drinking water containing lead above drinking water standards include the following: W1, no action; W2, public information; W3, public information and residential treatment; W4, public information and alternative source, public utility; W5, public information and alternative source, groundwater; and W6, public information and multiple alternative sources.

Providing public information to educate citizens about the risks of consuming contaminated water was considered key to controlling these risks. However, consumer education alone was considered insufficient, and some method of making uncontaminated water readily available was considered essential. Point-of-use filtration can be very effective but requires regular filter replacement to be protective. Scheduled replacement of filters on water lines requires an extra level of public education, which would vary greatly in the general population. Hence, various approaches to providing clean water were proposed. Alternatives ranged from tapping into existing municipal water systems, to development of new water wells in uncontaminated subsurface strata, to development of multiple sources of clean drinking water—depending on the needs of communities.

House Dust

Aggressive measures are believed to be needed to protect residents, especially children, from lead-contaminated house dust in lead-contaminated areas. Alternative approaches proposed include the following: D1, no action; D2, information and intervention and vacuum loan program/dust mats; and, D3, information and intervention, vacuum loan program/dust mats, interior source removal, and contingency capping/more extensive cleaning.

A public information program to inform citizens about the risks of exposure of children to lead in house dust has been administered by the Lead Health Intervention Program in the Bunker Hill box since 1985 and throughout the basin since 1996 (von Lindern 2004). Hence, alternatives developed for house dust would include information and intervention with “pamphlet distribution, press releases, public meetings, and publicly-posted notices to inform the public of remedial actions and to provide exposure education” (EPA 2002, p. 9-5). Alternative D2 would also include a heavy-duty vacuum loan program similar to the one previously used in the Bunker Hill box, coupled with free dust mats for entryways. Monitoring would be conducted for achievement of RAOs. The most aggressive alternative, D3, in addition to features of D2, would include interior source removals such as “one-time cleaning of hard surfaces and heating and cooling systems and removal and replacement of major interior dust sources such as carpets and some soft furniture” (EPA 2002, p. 9-6). Attics and basements would be cleaned and crawl spaces beneath houses, if contaminated, would be capped with sand or covered with synthetic membrane to prevent recontamination of houses.

Aquatic Food Sources

Three alternatives were developed to protect recreational fishermen, and perhaps subsistence fishermen, from risks associated with eating fish caught in contaminated areas of the Coeur d’Alene River basin: F1, no action; F2, information and intervention; and F3, information and intervention and monitoring.

The alternatives for protection of individuals from the risks associated with the consumption of contaminated fish caught in the Coeur d’Alene River, lateral lakes, and Lake Coeur d’Alene heavily focus on educating fishermen and recreational users about the potential health risks involved. All of the public information programs to educate citizens about the dangers of lead exposure would also include warnings about consuming contaminated fish. “A well-managed signage program to educate fishermen and other water users of metal hazards would be implemented at all river/lake access sites and common use areas, including the Coeur d’Alene River Trail system corridor. Idaho Department of Fish and Game, Idaho State Parks, USFS [U.S. Forest Service], and BLM [Bureau of Land Management] field personnel who regularly contact basin fishermen and recreational users would be trained in metals risk management and supplied with appropriate pamphlets and signs” (EPA 2002, pp. 9-6 to 9-7).

The more aggressive Alternative, F3, would, in addition to the broad-based educational program in Alternative F2, include a fish-flesh sampling program to provide lake-specific recommendations and identify those areas free of metal risks so fishermen could be notified accordingly. In addition, a trained river ranger program would be developed to advise fishermen and direct them to aquatic resources with the known lowest risks.

BOX 8-2 Alternatives for Environmental Protection

Upper and Lower Basin

Six alternatives were developed to mitigate ecologic risks for waterfowl, other birds, fish, and plants in the combined upper basin and lower basin: Alternative 1, no action; Alternative 2, contain/stabilize with limited removal and treatment; Alternative 3, more extensive removal, disposal, and treatment; Alternative 4, maximum removal, disposal, and treatment; Alternative 5, state of Idaho cleanup plan; and Alternative 6, mining companies' cleanup plan.

No Action

Under the no-action alternative, the Coeur d'Alene River basin would be left to recover naturally over an undeterminably long period of time (close to a millennium for fish according to EPA estimates) assisted by the remedial work already done in the Bunker Hill box and other locations in the upper basin.

Remedial Alternatives 2, 3, and 4

Alternatives 2, 3, and 4 progress from containment and stabilization of contaminated sediments with limited removal and treatment to more extensive removal, disposal, and treatment, to maximum removal and treatment. Alternative 2, in-place and on-site containment and stabilization "would be used to control ecologic and human exposures and metal transport via erosion and leachate loading to groundwater and surface water" (EPA 2002, p. 9-8). Bioengineering, involving planting vegetation, would be used in Alternative 2 to stabilize banks and streams, control erosion, and promote natural recovery. Passive chemical treatment systems would be used to treat drainage from mine adits and groundwater collected from hydraulic isolation systems.

In Alternative 3, in addition to the contain-and-stabilize strategy proposed in Alternative 2, regional repositories would be built for disposal of contaminated materials removed from the upper basin. A regional active water treatment plant would treat contaminated groundwater, leachate, and adit drainage water. Riverbed and bank sediments would be removed and stored in regional repositories. Inaccessible floodplain sediments would be subjected to hydraulic isolation.

Alternative 4 proposed the most aggressive approach for protecting ecologic receptors by maximum removal and disposal of sources of contamination, use of active water treatment, and hydraulic isolation of contaminated sediments.

State of Idaho Plan (Alternative 5)

The state's plan is most similar to Alternatives 2 and 3, which focus on containing and stabilizing the largest sources of metals loading. It includes regional repositories and passive water treatment to "achieve a balance between benefit, cost, and impact to the environment in both the long term and short term" (EPA 2002, p. 9-9). Appendix AA of the FS (URS Greiner, Inc. and CH2M Hill 2001b) outlines this plan.

Mining Companies' Plan (Alternative 6)

The mining companies' plan for remediating sources of metal contamination due to leaching of tailings to the Coeur d'Alene River basin stresses regrading and/or removing source material and stabilizing stream banks with vegetation. However, the plan does not include regional repositories. Appendix AB of the FS (URS Greiner, Inc. and CH2M Hill 2001b) outlines this plan.

Lake Coeur d'Alene

Two alternatives were developed for Lake Coeur d'Alene: no action and institutional controls. The only area evaluated that had health risks, Harrison Beach, has been remediated through Union Pacific Railroad actions; hence, institutional controls focus on developing a lake management plan to achieve water-quality goals through management of nutrients, primarily nitrogen and phosphorus. The desire to limit input of nutrients to the lake is based on the hypothesis, as yet unproven at this site, that eutrophication of the lake will increase the flux of metals from bottom sediments that eventually will reach the Spokane River. Sewers will be managed to limit nutrient input to the lake, and control of near-shore erosion will limit sediment loading to the lake. Dredging and/or capping of contaminated lake sediments was not considered because of engineering and cost considerations.

Spokane River

EPA and the state of Washington collaborated to develop five alternatives for risk management in the Spokane River between the state line and Upriver Dam: Alternative 1, no action; Alternative 2, institutional controls; Alternative 3, containment with limited removal and disposal; Alternative 4, more extensive removal, disposal, and treatment; and Alternative 5, maximum removal and disposal. Mining companies did not prepare an alternative.

Alternatives developed for the Spokane River are similar in concept to those proposed for the upper and lower basin of the Coeur d'Alene River, ranging from institutional controls, to containment and removal, to aggressive removal and disposal. Institutional controls would be limited to postings and notices to the public of potential risks and limiting vehicular traffic to reduce erosion and allow vegetation to naturally stabilize shorelines.

In Alternative 3, contaminated beach materials mostly would be left in place but covered with clean material. The physical characteristics of some areas could require limited removal and disposal or excavation and on-site consolidation. In Alternative 4, areas that would be capped in the previously described containment scenario would be excavated and disposed of off-site. Excavated areas would be backfilled with clean material. Sediments behind Upriver Dam that exceeded contaminant criteria would be capped in place.

A maximum removal and disposal option (Alternative 5) would remove and dispose off-site all contaminated sediments and beach materials, including the sediments behind Upriver Dam.

TABLE 8-4 Summary of Alternatives and Costs Developed for the Coeur d'Alene River Basin

Focus	Media/Area	Alternative designation	Description	Estimated total cost
Human health protection	Soils	S1	No Action	$0
		S2	Information and intervention	$5,410,000
		S3	Information and intervention and access modifications	$2,900,000
		S4[a]	Information and intervention and partial removal and barriers	$81,000,000
		S5[a]	Information and intervention and complete removal	$123,000,000
	House dust	D1	No action	$0
		D2	Information and intervention and vacuum loan program/ dust mats	$1,380,000
		D3	Information and intervention, vacuum loan program/dust mats, interior source removal, and capping/more extensive cleaning	$4,290,000
	Drinking water	W1	No action	$0
		W2	Public information	$428,000
		W3	Public information and residential treatment	$1,418,000
		W4	Public information and alternative source, public water utility	$10,000,000
		W5	Public information and alternative source, groundwater	$2,900,000
		W6	Public information and multiple alternative sources	$2,210,000

	Aquatic food sources	F1	No action	$0
		F2	Information and intervention	$230,000
		F3	Information and intervention and monitoring	$910,000
Ecologic protection	Coeur d'Alene River basin (including upper basin and lower basin)	1	No action	$0
		2	Contain/stabilize with limited removal and treatment	$370,000,000
		3	More extensive removal, disposal, and treatment	$1,300,000,000
		4	Maximum removal, disposal, and treatment	$2,600,000,000
		5	State of Idaho cleanup plan	$257,000,000
		6	Mining companies cleanup plan	$194,000,000
	Lake Coeur d'Alene	1	No action	$1,300,000
		2	Institutional controls	$8,800,000
	Spokane River	1	No action	$0
		2	Institutional controls	$900,000
		3	Containment with limited removal and disposal	$1,800,000
		4	More extensive removal, disposal, and treatment	$6,500,000
		5	Maximum removal and disposal	$28,000,000

[a]Based on removal, capping, and revegetation of soil with >1,000 parts per million (ppm) of lead in community areas (yards, rights-of-way) and >700 ppm of lead in common use areas in towns. Community areas between 700 and 1,000 ppm of lead would receive a vegetative barrier.
SOURCE: EPA 2001a.

EPA's Comparison of Remedial Alternatives

Remedial alternatives are compared to each other based on nine criteria described in Table 8-5. The first two criteria are requirements or "threshold" criteria: a remedy has to satisfy them to be considered unless EPA has issued a specific waiver under the second criterion. The next five are called "balancing" criteria. They are used in weighing the advantages and disadvantages of the potential remedies that satisfy the first two criteria. The last two criteria are called "modifying" criteria. If the public review of the proposed decision indicates strong opposition by the state or the community to EPA's proposal, the agency, at its discretion, can modify its decision in recognition of this opposition.

Human Health Risk in Communities

Comparative analysis of the alternatives led EPA to decide that the best balance of trade-offs would be represented by Alternative S4 for soil, D3 for house dust, W6 for drinking water, and F3 for food sources, as described above in Box 8-1.

Ecologic Receptors in Upper and Lower Basin

As described in Chapter 9 of the ROD (EPA 2002), EPA determined that Alternative 3, described above, represented the best balance of tradeoffs for a long-term cleanup approach in the upper and lower basin. This alternative entails massive removals of contaminated sediments from wetlands covering over 5,000 acres, riverbed sediments (20,600,000 cubic yards), and lower basin riverbank sediments (1,780,000 cubic yards). In addition, treatment of adit drainage, groundwater, and surface water in the upper basin would be necessary to meet ARARs. A metals load reduction of 57% was estimated at the completion of remedy implementation. The estimated cost of this alternative is $1.3 billion. It is important to note that ultimately Alternative 3 was not selected for implementation. As described below, the "selected remedy" is a subset of these actions.

Lake Coeur d'Alene

EPA selected the alternative of implementation of a multiagency lake management plan primarily to control sediment and nutrient loading to the lake.

Spokane River

EPA decided that the best balanced approach to managing metals contamination in the Spokane River would be a combination of the alternatives

TABLE 8-5 Evaluation Criteria for Superfund Remedial Alternatives

Criterion		Description
Threshold criteria	Overall protection of human health and the environment	Determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment
	Compliance with ARARs	Evaluates whether the alternative meets federal, state, and tribal environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified
Balancing criteria	Long-term effectiveness and permanence	Considers the ability of an alternative to maintain protection of human health and the environment over time
	Reduction of toxicity, mobility, or volume through treatment	Evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination remaining after remedy implementation
	Short-term effectiveness	Considers the length of time needed to implement an alternative and the risk the alternative poses to workers, residents, and the environment during implementation
	Implementability	Considers the technical and administrative feasibility of implementing the alternative, including factors such as the availability of materials and services
	Cost	Includes estimated present worth capital and operations and maintenance (O&M) costs. O&M costs are estimated for a 30-year period using a discount rate of 7%
Modifying criteria	State/tribal acceptance	Considers whether the states and tribes agree with EPA's analyses and recommendations, as described in the RI/FS and the proposed plan
	Community acceptance	Considers whether the local community agrees with EPA's analyses and the interim action. Comments received on the proposed plan during the public comment period are an important indicator of community acceptance

SOURCE: EPA 2001a, Table 7-1.

that could include capping of contaminated sediments, riverbed sediment removal, and possibly sediment removal from Upriver Dam.

Evaluation of EPA's Comparison of Alternatives

In the statement of task, the committee was asked to assess whether EPA adequately characterized "the feasibility and potential effectiveness of the remediation plans . . ., given best engineering and risk management practices and the site specific characteristics," and whether EPA considered an "adequate set of alternatives." In answering these questions, it is helpful to distinguish between those plans focusing on protecting human health and those focusing on environmental protection.

With respect to the remedies focused on protecting human health, it is the committee's judgment that the agency considered an adequate set of alternatives and adequately characterized the feasibility and potential effectiveness of these alternatives. The feasibility and effectiveness (or lack thereof) of most of the alternatives EPA considered have been demonstrated at other sites and within the Coeur d'Alene River basin in the cleanups conducted within OU-1 and OU-2. However, as discussed in Chapter 5, the evidence regarding the effectiveness of yard remediations for decreasing blood lead levels (BLLs) in children is not firmly established. Further, more consideration needs to be given to the protection and long-term maintenance of the soil-remediation projects from flood damage and recontamination by contaminated sediment carried by these floods. Similar concerns regarding the feasibility and effectiveness of remedies exist for the selected remedy and are examined in greater detail later in this chapter.

With respect to those alternatives considered for environmental protection, questions about feasibility and effectiveness are much more germane. In particular, the committee has concerns about the accuracy of the "probabilistic model" that the agency used to predict postremediation dissolved zinc concentrations and compare remedial alternatives; whether wetland remediations will be effective in decreasing waterfowl mortality; and whether removals of contaminated floodplain materials will effectively decrease zinc concentrations in surface water. Similar concerns exist for the selected remedy for environmental protection and are examined in greater detail later in this chapter.

On the topic of whether EPA considered an adequate set of remedial alternatives, the committee is concerned that the agency has not identified any alternatives addressing the primary source of dissolved zinc loadings to the middle basin—groundwater discharges in the box (see Chapters 3 and 4). Not addressing this problem will make it much more difficult, probably impossible, to achieve water-quality standards and provide adequate protection to native fish populations. The committee also believes, similar to the case of the human health protection alternatives, that EPA has overestimated the durability of its proposed actions and should have considered alternatives that provided more protection against flood damages and the deposition of contaminated silt during flood events.

As it turns out, however, much of the effort expended by EPA to identify and evaluate alternatives for ecologic protection seems to have been for naught. None of the identified alternatives were selected, and it is unclear whether even the selected remedies will be implemented.

SELECTED REMEDY: GEOGRAPHIC AREAS, LEVELS OF REMEDIATION, AND REMEDIATION PLANS

EPA presented its "preferred alternative" in the proposed plan (EPA 2001a). This preferred alternative is an "interim action" and represents the first increment in a long-term response. For human health, "The interim action includes all of the remedy for protection of human health in the communities and residential areas of the Upper Basin and the Lower Basin." For environmental protection, "The interim action consists of the first increment of cleanup, and the remedy consists of 20 to 30 years of prioritized Ecological Alternative 3 actions" (EPA 2001a, p. 8-1). Following public and stakeholder review and input on the preferred alternative outlined in the proposed plan, a selected remedy is documented in an ROD (URS Greiner, Inc. and CH2M Hill 2001a, Part 1, p. 1-4).

The selected (interim) remedy presented in the ROD for OU-3 contains limited changes from the preferred alternative and, for human health and environmental protection in the upper, middle, and lower basin (as well as the Spokane River), the selected remedy was also the preferred alternative (EPA 2002, pp. 12-5, 12-16, 12-44). This remedy is estimated to cost approximately $360 million (see Table 8-6). The selected remedy is described in four parts in Section 12, Part 2 of the ROD (EPA 2002):

1. Protection of human health in the community and residential areas of the upper, middle, and lower basins
2. Environmental protection in the upper, middle, and lower basins
3. Lake Coeur d'Alene
4. Spokane River

There are no remedial actions for Lake Coeur d'Alene, however, because a lake management plan (Coeur d'Alene Basin Restoration Project 1996, 2002; IDEQ 2004) is proposed, which is intended to be implemented outside of the Superfund process.

This section describes the selected and interim remedies outlined in the ROD (EPA 2002) for protecting human health and the environment and evaluates them in terms of the following:

- Rationale and decisions for determining levels of remediation
- Rationale and decisions for including or excluding geographic areas
- The feasibility and effectiveness of remediation plans

TABLE 8-6 Estimated Cost of the Selected Remedy

Area	Selected Remedy	Estimated Total Cost
Human health protection in the community and residential areas of the upper basin and lower basin	Full remedy, including soil and house dust, including yards, infrastructures, repositories, rights-of-way, commercial properties, and recreation areas	$92,000,000 Including:
	Alternatives S4 (information and intervention and partial removal and barriers) and D3: (information and intervention, vacuum loan program/dust mats, interior source removal, and capping/more extensive cleaning)	$89,000,000[a]
	Drinking water: Alternative W6 (public information and multiple alternative sources)	$2,200,000
	Aquatic food sources: Alternative F3 (information and intervention and monitoring)	$910,000
Ecologic protection in the upper basin and lower basin	Approximately 30 years of prioritized actions	$250,000,000 Including:
	Upper basin tributaries	$100,000,000
	Lower basin riverbanks and bed	$71,000,000
	Lower basin floodplains	$81,000,000
Lake Coeur d'Alene	Not included in the selected remedy	
Spokane River	Combination of elements of Spokane River Alternative 3, 4, and 5	$11,000,000
Monitoring	Basin-wide monitoring	$9,000,000
Total Cost		$360,000,000

NOTE: costs are rounded to two significant figures.
[a]Includes costs for residential soil, street rights of way, commercial properties, and common areas, 31 recreational areas in the lower basin, and house dust.
SOURCE: Adapted from EPA 2002, Table 12.0-1.

Human Health Selected Remedy

The selected remedy for the protection of human health is presented in Chapter 12 of the ROD and was developed to address exposure to metals (primarily arsenic and lead) in soil, drinking water, house dust, and aquatic food sources. Soil and dust from homes, the surrounding communities, and recreational areas are considered the dominant areas of risk (EPA 2002, p. 12-4). The selected remedy does not address certain potential exposures including recreational use in areas of the basin not addressed in the ROD, subsistence lifestyles, and potential future use of groundwater. The selected remedy for human health is further discussed in Chapter 5 of this report and is summarized in Box 8-3.

Human Health Risk and Levels of Remediation

Lead and arsenic contamination of soils in yards and recreational areas constitutes the primary human health risk in the basin. Substantial effort has gone into determining the level of contamination that presents an unreasonable risk and necessitates remediation (see Chapters 5 and 6). Once it has been determined that a particular yard needs to be excavated because the soil contamination lead levels exceed 1,000 mg/kg (or 100 mg/kg for arsenic), clean soil is used to replace the excavated materials.

The approach described for soil replacement is appropriate because children are exposed to lead in a number of different sources—including drinking water, inhaled and ingested dust and soil, food, and paint—and their risk of excessive exposure is an integral of all these separate exposures, some of which the cleanup may not address at all. Cleaning up one major source of exposure to below the threshold values allows other sources to remain high without creating an unreasonable risk for all the exposures considered together.

For lawns with contamination levels between 700 and 1,000 mg/kg, a "vegetative barrier" (grass, usually applied as sod) will be used. The amount of exposure reduction resulting from such a barrier is unclear and is likely to be highly site specific depending on factors such as how well the vegetation is maintained.[1] In other areas, the barriers may take the form of asphalt pavement or a layer of clean gravel or soil. In these cases, lead concentrations should be reduced, at least initially, to well below the action level.

Soil cleanups will be supplemented by a "health intervention program" and other actions. Parts of the health intervention program, such as information about public health risks, a vacuum cleaner loan program, and voluntary BLL tests, will be available to all residents in contaminated areas. Other parts of the supplemental programs will be more focused. For instance, homes with particularly susceptible residents, such as young children and pregnant women, will be monitored while the remedy is being implemented to ensure that exposure levels decrease to acceptable levels. Where they do not, further actions such as pressure cleaning the outside of houses to remove leaded paints or even relocation of residents may be undertaken. The agency, however, has not established any clear criteria for when these discretionary supplemental activities will occur.

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[1]This approach of using less-protective remedies in areas where the contamination is lower results in an apparent anomaly that the residual risks from contaminated yard soils facing children in homes with lower initial soil contamination levels will likely end up higher than those for children living in homes with high initial levels of yard soil contamination. Such anomalies, however, are typically inherent in the types of decisions that have to be made under any cleanup program about which areas should be cleaned up and how.

BOX 8-3 Selected Remedy to Protect Human Health

Soil and house dust

- Sampling: House dust will be sampled for houses with pregnant women or young children. Yards and other areas will be sampled to determine whether the lead concentration exceeds 700 mg/kg or arsenic levels exceed 100 mg/kg.
- Remediation of residential yards: For yards having a contamination level exceeding 1,000 mg/kg or an arsenic concentration exceeding 100 mg/kg, soils will be excavated to a depth up to 12 inches and replaced with clean fill. For yards having a contamination level between 700 mg/kg and 1,000 mg/kg, some type of barrier (usually vegetation) will be installed, which will be "continuous and sustainable" and will leave no bare soil exposed.
- Remediation of gardens: For gardens having a contamination level over 700 mg/kg, soils will be removed to a depth of 2 feet and replaced with clean soil.
- Remediation of street rights-of-way: Actions taken will depend on the "location, use, and contaminant concentrations" of the right-of-way. Possible actions include "access controls, capping (barriers consistent with land use), or removal/replacement."
- Remediation of commercial properties and common use areas: Depending on the location, use, and levels of contamination in these areas, remedial actions will include soil removal and replacement, barriers (such as vegetation or a cover of clean gravel or other material), and access restrictions.
- Remediation of recreational areas: EPA has identified thirty-one "formal" recreation areas for cleanup. In most cases where soil contamination levels exceed 700 kg/kg, the cleanup action will involve installing a nonvegetative barrier such as a cap of clean soil, gravel, or asphalt. In some cases, contaminated soils may be removed.
- Dust suppression during remedial activities: This will mostly include wetting down and covering exposed contaminated soils and site cleanup.

The remedies for contaminated drinking water supplies have many of the same characteristics as those for contaminated soils. The action levels, however, have no ambiguity. Contamination levels cannot exceed drinking water ARARs (unless the mining wastes are not the source of contamination). The selected remedies (alternative sources of drinking water or, if alternative sources are lacking, point-of-use filters) are expected to provide water supplies with contamination levels well below ARARs.

Thus, the fact that remedies proposed to protect human health in most cases will result in remediation levels substantially lower than action levels is reasonable. EPA has not explicitly said that it is following this rationale, but any effort to equate remediation levels to action levels would involve some clearly irrational actions to spend additional money to increase risks.

What the agency has not done, however, is provide a clear measure of whether its strategy is successful. Its RAOs are qualitative, not quantitative.

- Disposal of contaminated materials: Contaminated materials will be disposed of in safe repositories.
- Health intervention program: This includes a wide range of activities including education, monitoring the contamination levels in house dust, loaning vacuum cleaners, and voluntary tests of BLLs.
- Remediation of interior house dust, if necessary: If homes demonstrate high lead dust levels after their yards have been remediated, further cleanups may be undertaken. These could include interior cleaning and paint abatement.
- Relocation, if necessary: In a few cases, if remediation is infeasible or recontamination is highly likely, families can be relocated to cleaner dwellings.

Drinking water

- Public information: Residents on private wells will have the opportunity to have their water tested.
- Alternative sources: Where sampling shows that the drinking water supply exceeds drinking water ARARs, EPA will connect the house to an existing water supply system, dig a well into an aquifer with clean water, or provide a point-of-use filter.

Aquatic food sources

- Information: The Idaho Department of Health will provide information to commercial and recreational fishermen and post fish advisories near the lateral lakes. The department will also monitor contamination levels in fish from Lake Coeur d'Alene and issue advisories if high contamination levels are found.

Source: EPA 2002, pp. 12-5 to 12-12.

The agency states that "The Selected Remedy is expected to reduce the residual risk from lead in soil and house dust such that a typical child has no more than a 5 percent probability of having a blood lead level above 10 μg/dL and no more than a 1 percent probability of having a blood lead level above 15 μg/dL" (EPA 2002, p. 12-14). However, there is no way of measuring these probabilities, and thus no way of determining whether the cleanup is meeting their expectation. This lack of any quantitative, measurable, indicator of success is troublesome.

Feasibility and Potential Effectiveness of Remediation Plans

Coeur d'Alene River Basin

EPA has already implemented remedies like these in the box and at other Superfund sites and has demonstrated that they are feasible. Yard remediations have been conducted in the basin for the last several years; in 2004, over 300 yards were remediated. As indicated in Chapter 5, the available evidence indicates, with some caveats, that the selected remedy for human health (Box 8-3) can also be effective. One caveat relates to a reliance on education and information. Such activities often have very limited effectiveness and probably are not sufficient when risk levels are high. EPA appears to recognize these limitations and has not relied solely on these techniques when the agency has identified high risks.

A second caveat relates to the effectiveness of residential yard remediations for decreasing BLLs. Research to date has not definitively identified a causal link between remediated yards and decreased BLLs; however, a relationship between the two is reasonably expected (see Chapter 5 for discussion on this topic).

A third caveat relates to the need to maintain the remedies that do not completely remove contaminated material and use barriers to eliminate exposure. Vegetative barriers will fail if the vegetation is not maintained; caps can be eroded by floods or their integrity can be destroyed by traffic or excavation; water filters need to be maintained and periodically replaced; and gravel or asphalt barriers on streets and rights-of-way will degrade over time.

Further, none of the remedies is permanent, and the integrity of the remedies will have to be monitored and maintained, essentially in perpetuity, all of which constitutes a considerable financial burden. This has already been demonstrated in the box where floods and other actions have either eroded the installed remedies or caused recontamination. EPA recognizes this need, and the Panhandle Health District through the Idaho Department of Health and Welfare supervised the required monitoring and repair. This program appears to have been successful in correcting the problems caused by the 1997 flooding of Kellogg and Wardner, Idaho, by Milo Creek. Remedial activities following the Milo Creek flood were funded by the Federal Emergency Management Agency (FEMA). As presented in the OU-1 5-year review, "Given the financial status of the Bunker Hill Superfund Site cities and residents, it seems unlikely that cleanup from the Milo Creek flood would have occurred so efficiently, or at all, without FEMA funds" (TerraGraphics 2000, p. 6-8).

A major uncertainty associated with the yard and common-use area remediations is that these remedies call for institutional mechanisms to monitor their effectiveness, repair any failures, and remain in place and effective for an extremely long time (at least hundreds of years). As state funding priorities change and the situation in the Coeur d'Alene River basin loses its immediacy, maintaining an effective program is likely to be difficult. Various approaches have been considered for maintaining and funding institutional controls (See NRC 2003). For instance, one approach is the creation of trust funds to finance and oversee stewardship activities (Bauer and Probst 2000).

Lake Coeur d'Alene

EPA sampled beaches and wading areas adjacent to Lake Coeur d'Alene, and, with the exception of Harrison Beach, concentrations of metals did not exceed risk-based levels for recreation (EPA 2002, p. 5-8). Lead concentrations at Harrison Beach in Harrison, Idaho, on Lake Coeur d'Alene averaged 1,250 (mg/kg) (URS Greiner and CH2M Hill 1999), and the area has been remediated. Thus, no remedies have been proposed in the OU-3 ROD to reduce exposures in Lake Coeur d'Alene. However, recontamination of Harrison Beach from deposition of flood-mobilized contaminated sediment will likely occur in the future, so the remediation must be considered interim or short term and will need to be maintained. Consumption of lake fish represents an exposure pathway to metals, but limited information was available to assess the health risks of such exposures when the human health risk assessment was initially prepared. To address this data gap, EPA funded a special study to characterize the concentrations of arsenic, cadmium, lead, mercury, and zinc in the tissues of bass, bullhead, and kokanee in Lake Coeur d'Alene (URS Greiner, Inc. 2003). Results of that study were subsequently used to prepare a fish consumption advisory (IDHW 2003) that specifies the number of meals that can safely be consumed each month for those particular fish (and species with similar dietary behaviors). The advisory targets three population cohorts: the general population and children older than 6 years, pregnant and nursing women, and children younger than 6 years. In addition, the advisory adjusts the intakes according to the section of Lake Coeur d'Alene where the fish are caught. This fish-consumption advisory is a prudent method of risk management that not only balances the nutritional value of fish consumption with the potential harm of metal toxicity for those consuming the fish but also factors in the spatial variability of metal accumulation in fish.

Spokane River

The selected remedy for cleaning up shoreline areas along the Spokane River where residents go for recreation include controlling access, capping contaminated deposits, and removing 9,000-28,000 cubic yards of contaminated material (EPA 2002, p. 12-45 and Table 12.4.1). All these actions are feasible. Access controls may have limited long-term effectiveness unless they are monitored closely. Sites that are capped or excavated have a reasonably high probability of being recontaminated. EPA recognizes this possibility but apparently has not arranged with Washington for the state to establish a special institution, like that established for the Coeur d'Alene River basin, to monitor this problem and ensure that the cleanups are properly maintained.

No remedies have been proposed for the Spokane River to address risks from possible future uses of contaminated groundwater and risks to residents who engage in subsistence lifestyles. The agency does not have sufficient information to know the extent to which there are currently, or may in the future be, residents engaging in subsistence lifestyles or how high the risks would be to people who engage in such lifestyles. Future risks from contaminated groundwater could occur if residents extracted drinking water from a contaminated near-surface aquifer. However, in a recent study, the U.S. Geological Survey (USGS) reported that, although the Spokane River does recharge the aquifer along reaches, "trace elements were below drinking-water standards and guidelines, and most were below minimum reporting levels." Dissolved zinc is detected in groundwater adjacent to the river, but it did not penetrate appreciable distances into the aquifer (Figure 8-1) (Clark et al. 2004, p. 11). Because of its limited capacity to dissolve in water and its propensity to sorb to solids, lead is even less likely than zinc to affect groundwater resources in this area.

Selected Remedy for Ecologic Protection

The selected remedy is not one of the alternatives considered in the FS (URS Greiner, Inc. and CH2M Hill 2001a) for ecologic protection, although EPA believes that the level of cleanup described in Alternative 3 of

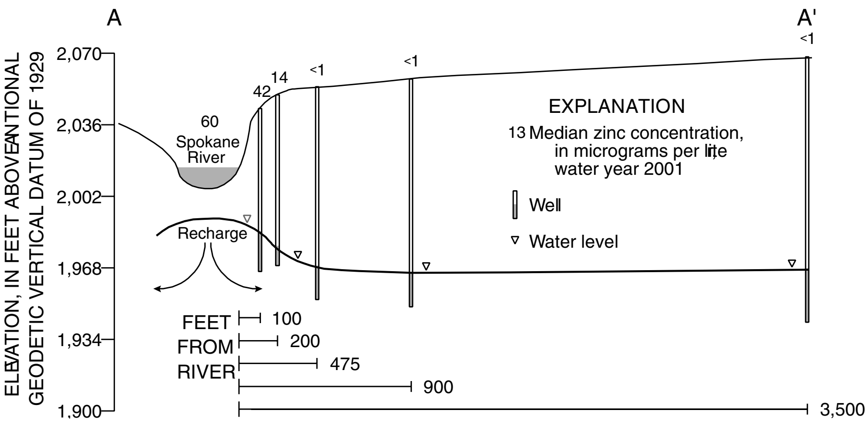

FIGURE 8-1 Water containing elevated concentrations of zinc displays limited transport from the Spokane River to the underlying Spokane Valley/Rathdrum Prairie aquifer. SOURCES: Clark et al. 2004; data from Caldwell and Bowers 2003.

the FS will be needed for protection of the environment and compliance with ARARs (EPA 2001a, p. 1-4). The selected remedy is an interim action and is generally a subset of the FS's Ecological Alternative 3 "extensive removal, disposal and treatment." The selected remedy focuses on three environmental problems in the basin: dissolved metals (principally zinc and cadmium) in rivers and streams, lead in floodplain soil and sediment, and particulate lead in surface water.

The remedy is not intended to fully address contamination within the basin, achieve ARARs, or attain the RAOs described in Table 8-3. CERCLA allows EPA to select an interim remedy, if it is part of the total remedial action that will attain all ARARs. The EPA National Remedy Review Board recommended interim remedial actions for protection of ecologic receptors in the basin, because of the magnitude of contamination to be addressed, the significant costs associated with a basin-wide remedial strategy, and the uncertainties associated with predicting the effectiveness of the basin-wide ecologic alternatives (NRRB 2001). The interim action decision for ecologic receptors gives EPA a very long time and the ability to experiment, try different remedial actions, evaluate progress, change course, and continuously seek ways to achieve the long-term goals of full environmental protection and compliance with ARARs. Interim action over 30 years is viewed by EPA to be a prioritized first increment of cleanup. However, as an interim action, it is intended to provide the best balance of tradeoffs for the following five CERCLA balancing criteria:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The long-term goals are to provide full protection of the environment as well as to return the opportunity for individuals to practice subsistence lifestyles without limits from mining contamination. EPA believes the interim approaches are consistent with these goals (EPA 2001a, p. 8-1).

The ROD (EPA 2002) recognizes that natural recovery will play a big role in improving the environmental quality of the basin. Time periods for natural recovery and achievement of ARARs are projected up to 1,000 years. Upfront aggressive cleanup activities are conceptually designed to hasten the recovery period. EPA intends to implement an incremental management approach for cleanup of the basin. Elements of this approach include the recently developed Basin Environmental Monitoring Plan (BEMP) (URS Group Inc. and CH2M Hill 2004) to measure cleanup progress, possible incorporation of innovative technologies that might be developed, prioritization of cleanup actions that may prove effective over time, and stakeholder involvement in prioritization of cleanup actions.

This section further explores factors the committee considers to be critically important in estimating the likelihood that proposed remedial actions will provide ecologic protection and includes the following:

- A brief discussion of contaminant distribution affecting ecologic receptors throughout the basin
- A consideration of the rationale and decisions for inclusion and exclusion of geographic areas for cleanup
- Assessment of EPA's cleanup actions
- An examination of EPA's use of the "adaptive management approach"

Contaminant Sources and Distribution in the Basin

Dissolved Metals

The main source areas of dissolved metals to the Coeur d'Alene River system are the upper basin (tributary streams feeding the South Fork Coeur d'Alene River) and middle basin (middle reach of the South Fork from Wallace to Cataldo). Zinc is the principal dissolved metal of concern. Woods (2001) showed that zinc represented about 99% of the total dissolved heavy metal load measured at Pinehurst in water year 1999. As discussed in Chapters 3 and 4, EPA's modeling estimates that 41% of the zinc load at Harrison (where the Coeur d'Alene River enters Lake Coeur d'Alene) stems from sources within the box. Canyon Creek contributes 15% of the zinc load at Harrison. Dissolved zinc contributions to the Coeur d'Alene River below Pinehurst account for 15% of the total zinc load at Harrison. These contributions are likely due to groundwater seeps in the Cataldo Flats area and mobilization of zinc associated with riverbanks and levees and from entrained water (pore water) in stream bed sediments (pore water concentrations of zinc in this area range from about 13,000 to 36,000 μg/L [Balistrieri et al. 2003]). Little of the dissolved metals in the river system come from discrete sources (for example, adits). An estimated 71% of the zinc load is derived from affected sediments and associated groundwater (EPA 2002, Figure 5.2-4). As described in Chapter 3 of this report, groundwater contamination by metals has been detected at locations throughout the river basin. The amounts of dissolved metal contributed by groundwater and the exact locations of groundwater influx to the river system are unknown, although EPA expects that most zinc in surface water is derived from groundwater influx (EPA 2004b [June 23, 2004]) (see discussion in Chapter 4 of this report).

Lake Coeur d'Alene exceeds water-quality standards for protection of aquatic life from dissolved cadmium and zinc. These standards are more stringent than drinking water standards. The lake retains on average about 38% of the zinc input based on the difference between metal load into the lake and load out of the lake (EPA 2002, p. 5-8). During flood events or high spring runoff from the Coeur d'Alene River, drinking water action levels for lead are exceeded in Lake Coeur d'Alene for short periods.

The water in the Spokane River meets safe drinking water standards for metals. The estimated average concentrations of total lead and dissolved zinc in surface water are 2.1 and 58 μg/L, respectively; dissolved cadmium was not detected (EPA 2002, p. 5-10). When total metals[2] were measured, 21% of the samples exceeded a cadmium screening level of 0.9 μg/L, 48% exceeded a 0.66 μg/L screening level for lead, and 68% exceeded the 30 μg/L screening level for zinc. Lead and cadmium screening levels are equal to federal ambient water-quality criteria (AWQC), and zinc is a risk-based concentration for protection of aquatic plants (EPA 2002, p. 5-10).

Particulate Metal: Tailings, Mine Wastes, and Mining-Affected Sediments

Waste rock dumps (uncrushed rock materials) and tailings piles (crushed rocks subjected to certain mineral processing steps) are located on hillsides, often very steep, and adjacent to mine adits along tributary streams in the upper basin where mining took place. In some cases, these materials are physically unstable, and sometimes they collapse into the stream. In other cases, for example at the Success Mine located adjacent to the East Fork of Ninemile Creek, groundwater interacts with the tailings, resulting in contaminated groundwater that feeds into the stream.

An estimated 62 million tons of tailings, containing about 880,000 tons of lead, were directly discharged to streams before 1968 (EPA 2002, p. 2-1). In streams and rivers, lead exists principally in the form of particles because lead minerals are relatively insoluble and any dissolved lead has a propensity to adsorb to metal oxyhydroxide particles. The present distribution of the approximately 880,000 tons of lead from released mill tailings is shown schematically in Figure 8-2, derived from analyses conducted by the USGS (Bookstrom et al. 2001; Box 2004). The lead-containing tailings mix with clean sediments throughout the length of the valley, greatly increasing the volume of streambed material that is affected. During spring runoff and flood events, streams overflow their banks, depositing metal-contaminated sediment on stream banks (Bookstrom et al. 2004).

[2]Total metal concentrations are determined by analyzing water that has not been filtered, using chemical digestion methods.

Approximately 24% of the lead from mill tailings released to the streams resides in the tributary streams of the South Fork Coeur d'Alene River and the middle reach of the South Fork Coeur d'Alene River (Wallace to Cataldo) (Figure 8-2). In these areas, there are about 7 million cubic yards of tailings-affected sediments including an estimated 3 million cubic yards of sediment that were used as fill or otherwise located beneath Interstate 90, other roads, and residential and commercial structures. These numbers do not include deeper, less-affected sediments (EPA 2002, p. 5-6). The ROD presents average sediment concentrations at various monitoring locations in the Coeur d'Alene River. For example, in the upper basin, above Wallace, the average sediment concentration of lead is 4,060 mg/kg; in the middle basin, below Wallace but above the box, it is 3,120 mg/kg; and sediment concentrations at a site located near Pinehurst are 9,330 mg/kg (EPA 2002, Figure 5.2-2).

About 29% of the released lead is located in the lower reach of the Coeur d'Alene River (Cataldo to Lake Coeur d'Alene) (Figure 8-2). The sediments in this stream segment are stratified vertically, with sediments containing high lead concentrations buried deeper, covered by sediments with lower lead concentrations (see Figure 3-9 in Chapter 3 of this report). The potential remobilization and transport of these highly contaminated sediments is a particular concern. Severe floods, such as the one in 1996, are capable of scouring the river bottom and mobilizing these sediments. Under less severe conditions, only the upper layer of less-contaminated sediments is redistributed. EPA estimates that 1.8 million cubic yards of bank materials and 20.6 million cubic yards of bed sediments are affected (EPA 2002, Table 9.2-8). Note the vastly larger volume of affected sediment in the lower reach of the basin compared with the volume in the upper

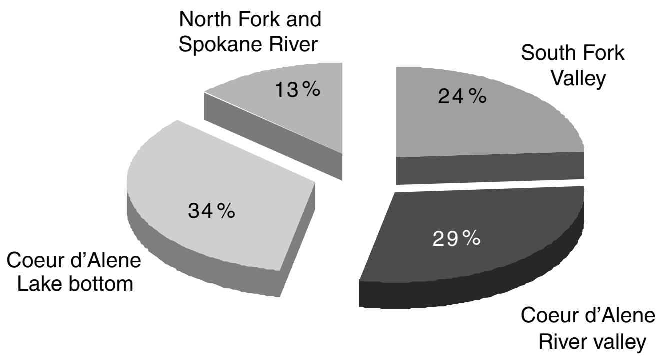

FIGURE 8-2 Distribution of approximately 880,000 tons of lead from mill tailings released to streams. SOURCES: Bookstrom et al. 2001, table 15; Box 2004.

and middle basins, collectively; yet, the percentage of distributed lead is nearly the same—29% in the lower reach compared with 24% in the upper and middle basins (Figure 8-2). The large volume of affected sediments in the lower reach of the main stem Coeur d'Alene River results from the mixing of North Fork and South Fork sediments. For example, in water year 1999, approximately 21,930 tons of sediment were discharged from the South Fork Coeur d'Alene River (URS Greiner Inc. and CH2M Hill 2001c, Figures 3.2-13 and 3.2-14) and mixed with approximately 25,400 tons of sediment from the North Fork (URS Greiner Inc. and CH2M Hill 2001d, Figures 3.2-4 and 3.2-5).

The average lead concentration in the floodplains of the lower reach of the Coeur d'Alene River is 3,100 mg/kg (EPA 2002, p. 5-7). An estimated 18,300 acres, or 95% of the 19,200 acres of floodplain habitat in the lower basin, contain more than 530 mg/kg of lead in the surface sediments. Figure 8-3, compiled by the USGS, shows lead distribution by depositional environment in the lower reach of the Coeur d'Alene River basin.

About 34% of the estimated 880,000 tons of released lead resides in the bottom of Lake Coeur d'Alene (Figure 8-2). This has resulted in an estimated 44-50 million cubic yards of contaminated sediments (EPA 2002, p. 5-8). The remaining 13% of the released lead is distributed between the North Fork of the Coeur d'Alene River and the Spokane River (Figure 8-2) (Bookstrom et al. 2001, table 15; Box 2004). The average concentration of lead in 265 sediment samples collected in the Spokane River floodway between Lake Coeur d'Alene and Long Lake is 400 mg/kg. An estimated 260,000 cubic yards of lead-contaminated sediments are present upstream of Upriver Dam (EPA 2002, p. 5-9).

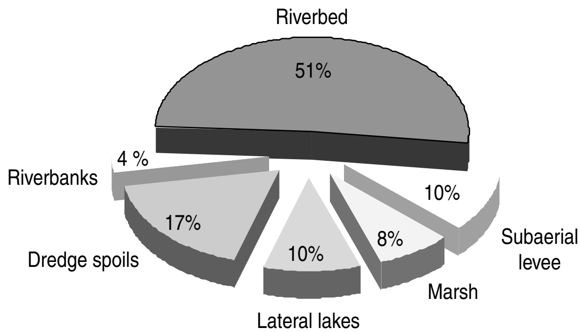

FIGURE 8-3 Distribution of lead by depositional environment in the lower reach (Cataldo to Harrison) of the Coeur d'Alene River. SOURCES: Bookstrom et al. 2001; Box 2004.

Ecologic Risks: Adaptive Management and Determining Levels of Remediation

The situation with respect to remediation levels for ecologic risks is similar to, but more complicated than, the situation with respect to human health risks. One major reason for the increased complexity is that the current ROD (EPA 2002) does not propose a final remedy; rather, the interim measures represent actions that "will neither be inconsistent with nor preclude implementation of the final remedy that will be identified in subsequent decision documents" (EPA 2002, Declaration, p. 6). EPA proposes to implement these interim remedies and conduct monitoring to determine their effectiveness. The agency refers to this approach as adaptive management. The selection of any final remedies will depend on information gained in implementing the interim remedies, some of which are admittedly experimental. The adaptive management approach and the rationale for determining remediation levels for the environment are discussed below.

Adaptive Management Approach

The ROD (EPA 2002) gives the concept of adaptive management only cursory mention. The BEMP (URS Group Inc. and CH2M Hill 2004) provides a more extensive discussion and defines adaptive management as follows:

> In general terms, adaptive management is a systematic strategy for continually learning from the ongoing monitoring results to cost-effectively improve future remediation and monitoring. It provides a purposeful feedback loop to assess evolving conditions and identify useful changes to the remedy, including long-term monitoring, as identified in the BEMP. Adaptive management is a key strategic component inherent in the BEMP. (URS Group Inc. and CH2M Hill 2004, p. 6-11)

The BEMP does not provide details on how decisions will be made to modify the remedy in response to newly available data; for this reason, the committee is not convinced that EPA fully understands or is properly implementing the principles of adaptive management. The adaptive management approach was first described by Holling (1978) and has since been widely adopted in natural resource management, especially in the Pacific Northwest (Lee 1993). It is the subject of an NRC study (NRC 2003) and similar approaches have been suggested for mining megasites (Moore and Luoma 1990).

Adaptive management is not synonymous with "trial and error." Adaptive management is a six-step process for defining and implementing management policies for environmental resources under conditions of high uncertainty concerning the outcome of management actions. A well-structured adaptive management plan contains the following interactive steps:[3]

1. Assessing the problem
2. Designing a management plan
3. Implementing the plan
4. Monitoring
5. Evaluating results obtained from monitoring
6. Adjusting the management plan in response to the monitoring results

These steps, described more definitively below and contrasted with EPA's actions, are usually conceived to be a cycle in which monitoring provides feedback for redefining the original problem, refining the management plan, and so forth. EPA's approach generally follows this process, but the separate steps and feedback mechanisms between the different steps have not been structured to maximize the effectiveness of the strategy.

Step 1: Assessing the problem. Assessing the problem begins by defining the scope of the problem, defining measurable management objectives and potential management actions, and specifying key indicators for each management objective. These indicators should be measurable attributes of the resource being managed, must be relevant to the objectives of management, and must be responsive to management actions. Multiple indicators should be identified, including indicators expected to respond in different time frames (short-term, medium-term, and long-term) and spatial scales (for example, site, watershed, and basin).

Conceptual or quantitative models are then developed and used to predict the potential effects of alternative actions on the indicators. Explicit forecasts are then made concerning the responses of the indicators to alternative management actions. Finally, key uncertainties are identified, and the implications of these uncertainties with respect to the effects of alternative management actions are described.

Under the Superfund process, the objective of the RI is to define the scope of the problem. The objectives of the FS are to define alternative management actions and develop conceptual or quantitative models to predict the potential effects of these alternative actions. As discussed further below, EPA has proposed a reasonable set of biological indicators for evaluating responses of fish communities to remedial actions intended to improve water quality but has not proposed an equivalent set of indicators for evaluating the effectiveness of sediment removal actions. Implications of

[3]This discussion is based on principles developed by the British Columbia Forest Service (BC Forest Service 1999, 2000) and the U.S. Department of Energy (DOE 1999).

uncertainties, especially uncertainties concerning the influence of groundwater sources on water quality and of flood-related transport on sediment quality, were not discussed in the ROD or in the BEMP.

Step 2: Designing a management plan. This step begins with an evaluation of the management alternatives identified in step 1. The alternatives are compared with respect to the likelihood of meeting the management objectives, cost, risk of undesired consequences, and other relevant criteria.

The literature on adaptive management distinguishes between active adaptive management and passive adaptive management. In active adaptive management, the plan is designed as a management experiment to discriminate between alternative hypotheses concerning the responses of resources to management. The actions selected are intended to maximize the power of the management experiment. In passive adaptive management, the plan is designed under the assumption that the most plausible or likely hypothesis is true, and the actions or set of actions that are forecast to have the most favorable outcomes under that assumption are selected. Although active adaptive management provides the most informative feedback to future iterations of the management cycle, it is often impractical to implement because of costs, risks, and irreversibility of actions.

After a management plan is selected, a monitoring protocol is designed. The protocol should specify the types and quantities of baseline data; the frequency, timing, and duration of monitoring; the indicators to be monitored at each interval; the appropriate spatial scales for monitoring different indicators; and the persons or organizations responsible for different aspects of monitoring. A data management and analysis plan must be specified. Finally, and most importantly, the indicator values that will trigger a change in the management actions or objectives must be specified.

Under the Superfund approach, EPA evaluates the management alternatives in the FS and selects the preferred management plan in the ROD. The agency presumes that it can accurately predict the effectiveness of the alternatives it evaluates, which supports the passive adaptive management approach, and at most Superfund sites this approach is adequate. However, several of the actions proposed for protecting fish and wildlife in the lower Coeur d'Alene River basin appear to have many of the characteristics of experiments, and an explicit active adaptive management approach might be more effective in the long run.

The agency has developed a monitoring plan (the BEMP) (URS Group Inc. and CH2M Hill 2004) but, as discussed below, has not established specific indicator values that could trigger a change in the management actions or objectives.

Step 3: Implementing the plan. Implementing the management plan is a simple matter of following the plan as specified. Circumstances requiring deviations from the original plan should be identified in advance and should be understood and agreed to by all stakeholders. Any such deviations must be clearly documented.

As indicated by formal and informal conversations with the committee, EPA has clearly begun thinking about implementation of the ROD (EPA 2002) and realizes that the proposed remedies may have to be modified, perhaps substantially, when this process is under way. The possible need to modify the remedies is also reflected in the BEMP (URS Group Inc. and CH2M Hill 2004, pp. 6-12 to 6-13) and is explicitly a component of the 5-year reviews that the agency carries out at every Superfund site. However, the circumstances and indicators that would require such deviations have not been defined, and it is not clear that EPA has discussed these possibilities with all of the stakeholders.

Step 4: Monitoring. Implementation monitoring should include three components: (1) monitoring for implementation or compliance (were the actions taken as planned?), (2) monitoring for effectiveness (did the plan meet objectives?), and (3) monitoring to validate the model parameters and relationships (which hypothesis is correct?). The monitoring protocols should have been established in step 2, designing a management plan, but were not.

Table 8-7 summarizes the RAOs, actions, benchmarks,[4] monitoring parameters, and target values for actions intended by EPA to reduce risks to aquatic receptors in the Coeur d'Alene River basin. The ROD includes forecasts of the effects of the proposed actions on the future values of these parameters. At least with respect to fisheries, these indicators appear to meet the requirements of adaptive management.

For terrestrial resources, the connection between management objectives, actions, benchmarks, and indicators is much less clear. Table 8-8 summarizes the ROD's approach to establishing performance measures for waterfowl and songbirds. For these receptors, the primary source of risk is particulate lead derived from streambed deposits and streambanks. The RAOs for these receptors are intended to prevent ingestion and dermal exposure to lead "at concentrations that result in unacceptable risks." This approach does not provide an explicit metric for unacceptable risk, in terms of a tolerable dose, an acceptable rate of mortality, or a range of acceptable population characteristics. The benchmark for feeding areas specifies an amount of clean habitat that should be provided; the benchmarks for toxicity simply specify that toxicity should be reduced.

Monitoring blood lead concentrations in waterfowl and songbirds is clearly essential for documenting whether the remedial actions are reducing

[4]Benchmarks (actions and criteria) are near-term objectives that serve as "landmarks and measures" to evaluate the progress of prioritized actions to achieve long-term goals of risk reduction (EPA 2002, 8-1 to 8-3; EPA 2001a, pp. 5-1 to 5-3).

TABLE 8-7 RAOs, Actions, Remediation Benchmarks, Monitoring Parameters, and Target Values for Actions Intended to Protect Aquatic Resources

RAOs (EPA 2002, Table 8-2)	Actions (EPA 2002, Table 12.2-1)	Remediation Benchmarks (EPA 2002, Table 12.2-1)	Monitoring Parameter(s) (URS Group Inc. and CH2M Hill 2004, Table 4-3)	Target Value (URS Group Inc. and CH2M Hill 2004)
Reduce loadings and discharges of dissolved metals to levels that satisfy surface water-quality standards	Stabilize stream beds, bank, and dumps subject to erosion; implement runoff controls; construct sediment traps (Canyon Creek, Ninemile Creek, Pine Creek, South Fork)	Reduce metals toxicity to downstream receptors	Dissolved metals concentrations	Tier 1 fishery: presence of migrating fish only (zinc concentration < 20× acute AWQC)
		Reduce dissolved metals loadings discharge from Canyon Creek by at least 50%	Fish diversity and abundance	Tier 2 fishery: presence of resident salmonids of any species (zinc concentration between 7× and 10× chronic AWQC)
	Treat creek water and groundwater at mouth of Canyon Creek	Improve conditions to allow: • Natural reestablishment of a salmonid fishery • Natural reestablishment of migratory corridors for juvenile and adult fish • Natural increases salmonid populations and improved spawning and rearing • A higher fish density		Tier 3 fishery: presence of 3 or more year classes of resident salmonids, including young of year
	Remove, contain, or treat significant loadings sources (various locations)			

SOURCES: EPA 2002; URS Group Inc. and CH2M Hill 2004.

TABLE 8-8 RAOs, Actions, Remediation Benchmarks, Monitoring Parameters, and Target Values for Actions Intended to Protect Waterfowl and Songbirds

RAOs (EPA 2002, Table 8-2-1)	Actions (EPA 2002, Table 12.2-1)	Remediation Benchmarks (EPA 2002, Table 12.2-1)	Monitoring Parameter(s) (URS Group Inc. and CH2M Hill 2004, Table 4-3)	Target Value (URS Group Inc. and CH2M Hill 2004)
Prevent ingestion of arsenic, cadmium, copper, lead, mercury, silver, and zinc by ecologic receptors at concentrations that result in unacceptable risks	Remove contaminated bank wedges from highly erosive areas	Increase waterfowl feeding area with lead concentration <530 mg/kg by 1,169 acres	Waterfowl population	Statistically significant increase
			Waterfowl blood lead	Statistically significant decline
	Stabilize banks and revegetate removal areas		Waterfowl mortality	Statistically significant decline
	Construct and operate sediment traps at four splay areas	Reduce sediment toxicity to diving ducks, dabbling ducks, and warm- and cold-water fishes	Songbird diversity and abundance	Statistically significant increase in abundance and diversity
Prevent dermal contact with arsenic, cadmium, copper, lead, mercury, silver, and zinc by ecologic receptors at concentrations that result in unacceptable risks		Reduce soil toxicity for riparian receptors	Songbird blood lead	Statistically significant decline
	Implement periodic removal of riverbed sediments in Dudley reach or other natural depositional areas			
	Reduce exposure using a combination of removals, capping, and soil amendments in areas of high waterfowl use, high lead, road access, and relatively low recontamination potential			
	Identify agricultural and other areas with lower levels of lead for cleanup to provide additional clean feeding areas			

SOURCE: EPA 2002; URS Group Inc. and CH2M Hill 2004.

lead exposures. However, the BEMP does not specify a particular target blood lead concentration that should be achieved to meet the objective of prevention of unacceptable risks to these receptors. Instead, the BEMP states the target as being a statistically significant decline in blood lead concentration. A small, but statistically detectable decline in blood lead concentrations might not substantially reduce the number of birds adversely affected by lead exposures.

Similarly, to be fully consistent with the principles of adaptive management, the BEMP should specify a target reduction in the number of waterfowl killed per year, in the fraction of the migratory population in the basin that is affected, or both. Simply monitoring for a decline in mortality will not guarantee that the objective of preventing unacceptable risks will be achieved.

The BEMP also calls for monitoring the abundance of waterfowl and the abundance and diversity of songbirds. It is not clear how either of these parameters is related to the RAOs. The use of these types of measures as monitoring parameters in the BEMP involves an implicit hypothesis that current levels of lead exposure are reducing (1) the abundance of waterfowl and (2) both the abundance and diversity of songbirds. This hypothesis was not tested in the ecologic risk assessment (ERA). The abundance of waterfowl using the basin could decline because of adverse environmental conditions occurring outside the basin, even if mortality due to lead exposure were eliminated. No evidence is provided in the ERA that songbird abundance or diversity has declined because of lead exposure (as distinct from deforestation and other habitat disturbances), and target levels of abundance and diversity that would occur if lead exposures were reduced have not been specified. Testing hypotheses concerning the causes of changes in abundance and diversity requires a substantially more complex monitoring plan than that developed by EPA. Simply measuring abundance and diversity will neither test hypotheses concerning effects of lead exposures nor determine whether the RAOs have been met. Thus, at least with respect to waterfowl and songbirds, the benchmarks and monitoring parameters clearly do not currently meet the requirements of adaptive management, at least as currently formulated.

Step 5: Evaluating results obtained from monitoring. This step involves comparing the results obtained from monitoring with the forecasts in step 1. The evaluation should explain why the results occurred and should include recommendations for future action.

EPA does not appear to have established any formal evaluation process aside from the 5-year reviews, although the agency has suggested that informal evaluations may occur more frequently. One serious weakness with the EPA approach, however, is that, because the agency did not establish any quantitative short-term indicators, the agency lacks clear measures on which to base these evaluations. The committee's confidence in EPA's approach would be much stronger if the agency had established such indicators and had more formally structured an ongoing evaluation process.

Step 6: Adjusting the management plan in response to the monitoring results. This step involves following through with the recommendations from step 5. The models used to make the initial forecasts should be updated, and the objectives of management should be reviewed and possibly adjusted. New forecasts are made, and management actions are revised as necessary. Presumably, this should occur during the 5-year reviews. In its BEMP, the agency sets forth the following questions, which are to be answered during these reviews (URS Group Inc. and CH2M Hill 2004, p. 6-12):

- Is the remedy functioning as intended by the ROD (addressed through statistical analysis of trends data for monitored parameters)?
- Does interpretation and evaluation of available data from the BEMP and other monitoring programs suggest new or refined understanding of basin processes that are relevant to the remedy (addressed qualitatively)?
- Are revisions or modifications to the BEMP warranted?
- Are exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?
- Has any other information come to light that could call into the question the protectiveness of the remedy?

These questions address most of the items listed above. Implicit in these questions is the possibility that EPA will revise the proposed remedies (not just the BEMP). Again, the weakness is that there are no clear indicators on which to base these decisions, and some modifications probably should not wait for 5-year reviews (although, as indicated earlier, EPA staff appears to anticipate making changes informally as they observe them to be necessary or appropriate).

Adaptive management, as described above, should be unequivocally incorporated into every step of the Superfund process, beginning with the RI. EPA's approach to ecologic protection in the Coeur d'Alene River basin includes many of the components of adaptive management, but it has not been established in an explicit, structured manner that establishes unambiguous links between management objectives, management actions, performance benchmarks, and monitoring indicators. The biggest weakness is that the agency often has not established a series of quantitative indicators, particularly short-term indicators that can be monitored to unambiguously determine the success or failure of the proposed remedial actions.

Ecologic Risks: Rationale for Determining Levels of Remediation

The remedies proposed for protecting waterfowl and fish differ in terms of rationale for defining cleanup goals and the complications associated with implementing remedies that will achieve the goals.

Waterfowl. EPA made a risk management decision to use a site-specific protective lead value of 530 mg/kg as the benchmark cleanup criterion for the soil and sediment in the lower basin. This level is identical to the lowest-observed-adverse-effect level derived in a waterfowl toxicity study conducted by Beyer et al. (2000). As described in Chapter 7, this level, based on high-quality site-specific research, is consistent with field observations, and is within the range of preliminary remediation goals (PRGs) developed in the ERA. No rationale was provided, however, for selecting this specific value rather than the substantially higher or lower values provided in the ERA.[5] Given the extensive reviews and analyses used to develop the range of PRGs provided in the ERA, the committee is surprised that a more complete documentation of the decision to select 530 mg/kg as the cleanup criterion was not provided.

The selected remedy proposes to remediate about 1,200 acres of the approximately 5,800 acres of wetlands having contamination levels above 530 mg/kg using a combination of removals, capping, and soil amendments (EPA 2002, Table 12.2-1) (details of this and other actions are discussed further below). Representatives of the Fish and Wildlife Service made informal comments to the committee indicating that they hope that even this partial cleanup will result in a significant decrease in risks to the waterfowl in two ways. One way results from the fact that, even if the waterfowl move back and forth between contaminated and remediated areas to feed, their average exposure, and therefore the risks they face, will be reduced. The second way is intended to reinforce this benefit; remediated areas will be replanted with vegetation believed to be particularly attractive to the waterfowl that inhabit or migrate through the Coeur d'Alene River basin. They hope to induce the waterfowl to remain in the clean areas, thus reducing their risks further.

The other major efforts to protect waterfowl involve removing contaminated sediments from the bed and banks of the lower reach of the Coeur d'Alene River to reduce the likelihood that the cleaned up areas will become recontaminated as well as to possibly reduce the transport of con-

[5]EPA does say: "While 530 mg/kg lead in soil/sediment may not be fully protective of aquatic birds and mammals, it will address 95 percent of the habitat area. Only 5 percent of the impacted area in the Lower Basin is estimated to have lead concentrations between 530 mg/kg and background. For these reasons, EPA believes that selection of 530 mg/kg lead as the benchmark cleanup criterion for soil and sediment is technically the best alternative available at this time" (EPA 2002, p. 12-39).

taminated sediment through Lake Coeur d'Alene to the Spokane River. This appears to be a largely experimental effort and EPA has not advanced new criteria for how much of this should occur or how to determine whether it is successful.

Fish. Derivation of the final remediation levels for protecting fish is more straightforward than the derivation of remediation levels for protecting waterfowl, but the process of achieving those levels is much more complicated. The remediation levels for protecting fish are defined by Idaho's water-quality standards for protection of aquatic resources, which are presumptive ARARs for the site. According to EPA's current interpretation of the NCP, the cleanup is not complete until these standards are achieved. According to EPA, additional measures may be needed to protect threatened species (for example, bull trout) and to protect and/or enhance the potential for the Coeur d'Alene River fishery to become a "blue ribbon" trout stream.

As indicated later in this chapter, it is virtually impossible for EPA to achieve the water-quality standards by the remedy proposed in the ROD, because it does not address groundwater, which is the largest source of zinc loading to the river. EPA apparently is relying on a distinct (but currently unspecified) administrative structure to address groundwater issues.

A second complication is that contaminated water is only one of the threats facing the native species of fish—nonnative fish species and lack of habitat are other threats. For instance, nonnative fish species artificially introduced into the lateral lakes, Lake Coeur d'Alene, and the Coeur d'Alene River probably have permanently altered the fish communities of the basin and may impede or even prevent the reestablishment of viable populations of native species, even if water quality standards were achieved. Moreover, even if remediation improved water quality sufficiently to protect the health of fish, habitat restoration still would be needed to support macroinvertebrate and fish populations (see discussion in Chapter 7). A key factor relating upstream biotic communities in the Coeur d'Alene River with downstream segments is that habitats are linked in river systems (Vannote et al. 1980; Minshall et al. 1992). Good-quality riparian habitats and substrates for benthic invertebrates lead to quality trout stream fisheries. The fish, particularly salmonids, in Rocky Mountain streams are adapted to cold, clear waters (Baxter and Stone 1995). Maintaining riparian zones will optimize the biodiversity, as there are more microhabitats to exploit by benthic invertebrates and fish. Trout populations are also sensitive to sedimentation of spawning grounds and mitigation efforts will need to minimize any increase in the percentage of fine sediments as a result of, for example, bank removal or river bottom dredging practices.

Thus, in the case of fish, the ARARs represent a clear, measurable indicator of when the cleanup is successful. However, it may not be possible to achieve the ARARs, and, even if they are achieved, improved water quality alone may not be sufficient to ensure the viability of the fish populations of concern.

EPA could exempt the cleanup from meeting water-quality standards if the agency could demonstrate that fish and aquatic life can be protected without achieving these standards. In principle, such an exemption could be justified if monitoring data showed that aquatic populations and communities in the Coeur d'Alene River and its tributaries had the same characteristics as populations and communities in comparable streams unaffected by mining wastes. The approach of using biological indicators rather than chemical concentrations to evaluate water quality is well-established in the scientific literature (Karr and Chu 1999). The EPA Office of Water has published a guidance document on the development of biological indicators (also termed "biocriteria") and has advocated the use of biological indicators in state water-quality programs (Barbour et al. 1999).

Further precedent for using biological indicators in lieu of numerical water-quality standards as remediation goals is provided by the approach adopted at the Lower North Potato Creek (LNPC) site in Polk County, Tennessee, the largest and most severely degraded metal-mining site in the eastern United States (EPA 2001b; TDEC Lower North Potato Creek Voluntary Oversight and Assistance Program Order, January 4, 2001). Remediation of the LNPC site is being managed under EPA's Superfund Alternatives Program, under a Memorandum of Understanding between EPA, the Tennessee Department of Environmental Conservation (TDEC), and Glenn Springs Holdings Company (GSH). Performance goals for site closure are provided in a consent order between TDEC and GSH. According to the order, remediation will be considered complete when all on-site streams meet Tennessee's biologically based water-quality criterion for the region where the site is located. Tennessee's region-specific biocriteria, which were developed with methods documented in EPA's (1999) guidance manual, are specified in terms of aquatic community characteristics found in a suite of reference streams that are relatively unimpaired by chemical contamination or habitat disturbance. A stream is considered to be unimpaired if a standardized index of aquatic community quality measured in that stream exceeds the applicable regional value, even if Tennessee's numerical water-quality criteria (which, for metals, are the same as Idaho's criteria) are not met.

A biologically based approach to determining when sufficient protection has been achieved is consistent with EPA's approach to developing interim fishery benchmarks. The agency has defined a series of five "fishery tiers" that qualitatively describe the health of the fish communities present in the river. Methods documented in EPA guidance and other published literature could be used to develop a more rigorous set of indicators that could be used both to measure the progress of restoration and to develop quantitative closure criteria that would achieve the intent of the ARARs even if the numerical standards were not met.

Biologically based indicators of restoration success would have the additional advantage that, because they reflect both water and habitat quality, they could be used to determine the need for and the success of habitat restoration actions. Establishment of biologically based restoration goals still would require EPA and Idaho to consider the influence of introduced species and also of irreversible habitat alterations (for example, channelization, road construction) that probably will prevent the Coeur d'Alene River from ever being returned to premining conditions.

Remediation: Geographic Areas and Feasibility and Potential Effectiveness of Plans

EPA outlines remedial actions for environmental protection in the basin over the next 30 years. The committee looked at these interim actions and answered the following questions:

- What remedial actions are proposed?
- What areas of the basin were included and excluded in the remedial plans? What was the basis for the decision to include or exclude areas?
- What cleanup has already been done, and was this remediation effective?
- Are the planned remedial actions feasible?
- Will the cleanup be effective in meeting the agency's goals or benchmarks?

These questions are addressed for the following five topographical areas of the basin:

- Upper basin, which includes the high-gradient streams that flow into the South Fork Coeur d'Alene River
- Middle basin, which extends from Wallace to Cataldo
- Lower basin, which extends from Cataldo to Lake Coeur d'Alene
- Lake Coeur d'Alene
- Spokane River

EPA uses a probabilistic model to quantify the certainty that a proposed remedy could meet cleanup goals (URS Greiner, Inc. and CH2M Hill 2001e, p. 1-4). Because many of the remedial actions described in the ROD for the basin are based on the probabilistic model results, this model is assessed.

Assessing the Probabilistic Model

There were two primary functions of the probabilistic model. First, in the RI (URS Greiner and CH2M Hill 2001f), the model is used to statistically evaluate extensive data sets of surface-water dissolved zinc levels to probabilistically characterize current metal loading and concentrations in the river and provide an "expected value" or estimate of current conditions. The second function, used in the FS (URS Greiner, Inc. and CH2M Hill 2001a) and the ROD (EPA 2002), was to quantify the effect that remedial measures would have on surface-water concentrations and metal loadings and the certainty and time frame that a remedial alternative or a proposed remedy would meet cleanup goals, which may be AWQC or interim benchmarks (URS Greiner, Inc. and CH2M Hill 2001e, p. 1-3).

As described in Chapter 4, the first function (the estimated mass-loading analysis provided in the RI) provided a concise and useful tool for understanding expected contributions of zinc to surface waters at locations along the river system. However, using this model to provide estimates of postremedial effectiveness and surface-water concentrations in the future is problematic.

EPA uses the probabilistic model to estimate postremediation metal loadings at selected stream-monitoring locations. Metal loadings are estimated indirectly by using relative loading potentials (RLPs), representing metal loads per unit volume of waste material. An estimated RLP is used for each source type (for example, waste rock, floodplain material). In this analysis, it is hypothesized that postremediation loading reductions are proportional to the volume remediated (URS Greiner, Inc. and CH2M Hill 2001e, Section 2.4). Predictions of what metal load reductions might be achieved are estimated for up to 1,000 years in the future. The probabilistic model is only used by EPA to evaluate dissolved zinc. However, the results are used to predict the behavior of other dissolved metals (URS Greiner, Inc. and CH2M Hill 2001e). Figure 8-4 presents the results from the probabilistic model analysis on the impact that the various alternatives presented in the FS (see Box 8-2) will have over time. In this figure, surface-water concentrations of zinc (shown as a multiple of the AWQC) over time are modeled over 1,000 years for the various alternatives. This analysis shows, for example, that under Alternative 3 (an alternative containing substantial source removals), the surface-water zinc concentrations at Pinehurst, Idaho, would decrease below the AWQC in 400 years compared with 900 years for the no action alternative. (Note that, because of OU segmentation, this analysis does not include metals contributions from the box that, at Pinehurst, would more than double the zinc loads considered [EPA 2002, p. 5-6].[6]) Several logical and technical issues are

[6]As noted in the ROD (Figure 10.2-3): "If historic loadings from the Box were included without any future reduction, AWQC multiple would increase by a factor of approximately: Alt 1, 2.1; Alt 2, 2.6; Alt 3, 4.0; Alt 4, 5.2; Alt 5, 2.3, Alt, 6 2.2."

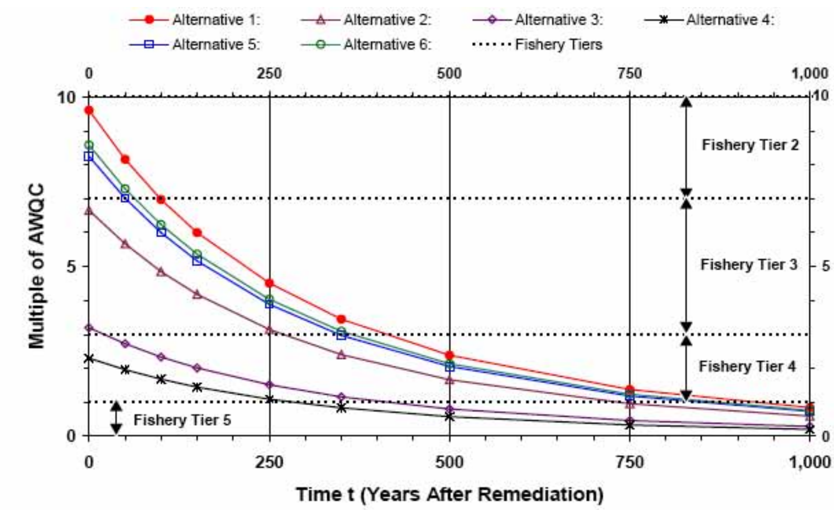

FIGURE 8-4 Comparison of the expected concentrations of dissolved zinc in surface water (presented as a ratio of the AWQC) over time at Pinehurst. Results are presented without including Bunker Hill box contributions. SOURCE: EPA 2002, Figure 10.2-3.

associated with this model and its use in extrapolating the effect of proposed remediation to 1,000 years, including the assumption that the impact of remedial strategies on the release of metals from source material to surface waters is known.

In essence, the probabilistic model estimates relative loading potentials based on estimated total volume of contaminated material, estimated concentration of available zinc, and estimated effectiveness of various remediation methodologies in reducing metal loading. The contribution of the box to dissolved metal loading is ignored, although a factor is provided that allows the box contribution to be considered.

The committee has serious doubts about the reliability of the probabilistic model to predict postremediation effectiveness. The model is based on an untested hypothesis for which no theoretical or experimental evidence is presented. For example, there are no leach test data from sediments or tailings, which would provide rates and quantities of metal release over time, allowing extrapolation of relative loading potential. Groundwater flow and metal concentrations data are not used in developing the model, although such data are available. There are no data on the effectiveness of various remediation methodologies in reducing "relative loading potential." No formal attempt has been made to calibrate the probabilistic model in a rigorous sense other than the "calibration" that is inherent in the model's use of statistical results from historic monitoring data as the preremediation condition (EPA 2004b [July 27, 2004]) even though there have been substantial source removals and associated monitoring in the South Fork and tributaries of the Coeur d'Alene River. The overall statistical procedure and supporting technical assumptions have not been externally peer reviewed. A committee member prepared a detailed mathematical assessment of the probabilistic model for estimating metal loading and effectiveness of remedial action; it is presented in Appendix F.

Remedial Actions Proposed for Upper Basin Tributaries: Ninemile Creek, Canyon Creek, and Pine Creek

Areas slated for cleanup in the upper basin encompass Ninemile Creek, Canyon Creek, and Pine Creek. Many of the primary sources (for example, mine workings, waste rock, and tailings) of dissolved metal contamination are located in the high-gradient streams that flow into the South Fork Coeur d'Alene River. Ninemile and Canyon Creeks also have contaminated in-stream sediments and influxes of contaminated groundwater. Table 8-9 summarizes EPA's cleanup goals, planned actions, and estimated costs. Interim cleanup measures described in the ROD (EPA 2002) for Ninemile, Canyon, and Pine Creeks are anticipated to cost $85 million.

The selected remedy for environmental protection in Ninemile, Canyon, and Pine Creeks consists of cleanup actions that EPA thought could be implemented within a 30-year period and would make significant progress toward protecting the environment and ARAR compliance and that were effective, had implementability, and were cost effective—the balancing criteria for CERCLA (EPA 2002).

Ninemile Creek. Ninemile Creek has high surface-water concentrations of dissolved zinc, and the source areas of metals within this tributary are relatively well defined, with large contributions stemming from two mining areas on the East Fork. In the ROD, the probabilistic model was used to predict water-quality conditions consistent with fisheries tiers (see Table 8-7) that would result from various response actions including the installation of a pond to treat water in the East Fork before its confluence with the main stem of Ninemile Creek. The lack of available space for a regional repository for contaminant removals was also a factor in the remedial plan decision for Ninemile Creek.

Cleanup activities have been under way by the mining companies and the state of Idaho at the Success and Interstate Mill site on the East Fork of Ninemile Creek. Harvey (2000) suggests that streambed and floodplain sediment removals at the Interstate site appear to be effective in reducing zinc loading in the stream; however, EPA has commented that they are

TABLE 8-9 Goals, Remedial Actions and Costs for Upper Basin, High-Gradient Tributary Streams

Location	Remedial Goal/Benchmark	Planned Actions	Estimated Cost of Cleanup (Present Worth[a])
Ninemile Creek	Re-establish fishery above Success Mine and migration corridor below Success Mine	Evaluate success of past/current floodplain tailings removal and water treatment at Success mine; if these actions do not achieve goal, may remove and relocate tailings and cap tailings, stabilize stream banks, and install a surface-water treatment pond; potential additional actions at the Rex and Interstate mill sites	$13.5 to $36 million
Canyon Creek	Reduce, by at least 50%, dissolved and reduce particulate metal loads discharging from the creek into the South Fork	Intercept and treat creek water, possibly using passive treatment with active treatment components; stabilize mine dumps and stream banks at 11 locations	$35 million
Pine Creek	Improve conditions to allow natural increases in salmonid populations, particularly native fish, and allow spawning and rearing	Stabilize stream bank and bed; revegetate near stream; in-stream, hot spot removals	$14 million
Upper South Fork Coeur d'Alene River	Improve conditions to support a higher fish density and initial protection of riverine and riparian receptors	Stabilize and bioengineer stream channel and banks to protect riverine and riparian receptors, with associated hot-spot removals in upper floodplain; address mine/mill sites with human health exposures	$16 million

[a]The first number is the estimated cost for the cleanup; the second number is the cost with a contingency added.
SOURCE: EPA 2002.

unaware of analyses on the effectiveness of the remedial activities in Ninemile Creek (EPA 2004b [September 17, 2004]). The Silver Valley Natural Resource Trustees[7] (SVNRT) installed a pilot-scale demonstration project at the Success Mine located on the East Fork of Ninemile Creek. The objective of the project is to demonstrate the viability of a groundwater collection and passive treatment system to reduce total and dissolved cadmium, lead, and zinc (Calabretta et al. 2004). Results from this demonstration project appear to be mixed. Although good removal efficiencies have been noted, they are not consistent, and serious problems in intercepting groundwater have been encountered. The demonstration project at Success Mine exemplifies EPA's hopes that such demonstrations will lead to acceptable, passive treatment technologies for other sites. The committee encourages EPA to continue such demonstration projects and work toward improving metal-removal efficiencies and groundwater interception. These types of passive technologies are desirable for treating small or intermittent flows that come into contact with contaminated sources that cannot be excavated (for example, fill under Interstate 90 or tailings pile and adit drainages that are in remote areas with limited access).

The cleanup plan for Ninemile Creek (Table 8-9) is largely a "wait and see" plan. If the contaminant removals and groundwater treatment accomplished to date do not achieve the goals of reestablishing the fishery above the Success Mine and the migration corridor below the mine, then additional actions as outlined in Table 8-9 will be taken, including source removal and installation of a treatment pond to collect and treat creek water with the objective of removing 60-70% of the zinc load from the East Fork. The committee fully supports the agency's plan to undertake the removal of sources contributing metals to surface water, encourages stabilization actions, and endorses actions that couple fish habitat restoration with remedial actions. Without habitat restoration, achieving the goal of reestablishing a resident fishery is doubtful. Treatment of East Fork creek water would entail constructing a facility to process 10 cubic feet per second (nearly 4,500 gallons per minute). Passive treatment of this volume of water in the limited space of the canyon is expected to be difficult.

Canyon Creek. EPA considered source-by-source cleanup in Canyon Creek and concluded that this approach, which would require extensive removals, would be costly and difficult to implement in the 30-year time frame of the selected remedy. The agency also believes that the effectiveness of source-by-source removal in Canyon Creek is uncertain (EPA 2002, p. 12-27). It is unclear to the committee how EPA arrived at this conclu-

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[7]The Silver Valley Natural Resource Trust Fund was formed in 1986 to administer a $4.5 million settlement between the state of Idaho and several mining companies operating within the Silver Valley.

sion, because source removal or stabilization of sources is fundamental to any remediation effort. Canyon Creek also remains a significant source of particulate lead, which continues to wash downstream during spring runoff and flood events. Until the sources of the particulate lead are removed from the floodplain or otherwise stabilized to prevent erosion, these sediments will continue to recontaminate downstream areas that have been or are proposed to be remediated. Although not explicitly stated by EPA, disposal of large volumes of source material removed from streambeds and other locations may be a serious issue given problems in finding suitable repository sites in the narrow, steep area of Canyon Creek. EPA recognizes that Canyon Creek is a major contributor of dissolved metals (about 15% of the dissolved zinc load at Harrison) to the river system and that groundwater downstream of the Hecla-Star tailings ponds contributes high concentrations of metals. It is unclear, however, how much of the groundwater contamination in lower Canyon Creek is attributable to the Hecla-Star tailings impoundments, because no definitive studies have been carried out. Erosion is observed along the side of the ponds (URS Greiner, Inc. and CH2M Hill 2001g, p. 2-7) and significant total lead and total zinc concentrations have been measured in water from seepage areas (EPA 2004b, [July 27, 2004]). Water from the Star adit is currently discharged to the Hecla-Star tailings impoundment (number 6) under a National Pollutant Discharge Elimination System permit. It is possible that this adit water is percolating through the tailings and contributing to groundwater contamination (EPA 2004b, [July 27, 2004]).

The SVNRT conducted floodplain sediment removals in Canyon Creek. One assessment by the state of Idaho (Harvey 2000) shows variable results: after removal actions, the zinc load was estimated to decline 59% under high discharges but increase 43% under low discharges. EPA considers this analysis to be based on "questionable data and fundamentally flawed analysis." EPA's analysis shows a small decrease in soluble zinc concentrations at low flow, but not high flows (EPA 2004b [July 27, 2004, and September 17, 2004]; C. Vita, URS, personal commun., September 20, 2004). As such, it is unclear if the removals conducted to date have a beneficial effect on stream-water metal concentrations. However, efforts to determine a causal relationship are confounded by limited data, a possible delay between the removal and resultant decrease in water concentrations, and the fact that the contaminated floodplain material from Woodland Park was moved to an unlined repository at the same site and apparently is serving as a source of dissolved metals to the groundwater. These issues reinforce the need for a rigorous site characterization to identify those sources contributing metals to surface water.

Stabilization of waste rock dumps and stream banks in areas around 11 mines is included in the selected remedy for Canyon Creek (Table 8-9). The committee fully endorses these actions. The ROD discusses plans to intercept groundwater and surface water near the mouth of Canyon Creek and treat this water. This plan proposes evaluating pond treatment and using passive treatment technology. The ROD anticipates that treatment of 60 cubic feet per second (about 27,000 gallons per minute) would be necessary to achieve the benchmark of 50% reduction of dissolved metal loading. In verbal discussions with EPA during the committee's tour on April 14, 2004 (EPA 2004c), agency personnel indicated they may be rethinking the idea of passive water treatment technologies for remediating surface flows from Canyon Creek and that active treatment may be used.

Treating the Canyon Creek water at the mouth of the stream will do nothing to meet EPA's overarching objective of protecting aquatic species in Canyon Creek. Moreover, the committee has considerable doubt about the efficacy of passive treatment technology for this application. Large volumes of water requiring treatment and the long retention times[8] needed demand a very large area for the passive treatment, and such an area is not available in the confines of Canyon Creek. Passive treatment systems also generate solid wastes that likely will be deemed hazardous waste, necessitating special disposal. Unprecedented innovations in passive treatment technology would have to occur over the next few years to effectively handle this situation. Active treatment technologies to treat large volumes of water are available; however, such systems also would require a large footprint,[9] generate metals-containing sludge that must be disposed, and, like passive treatment systems, are necessary in perpetuity. This remedy requires a state institutional mechanism to take full responsibility for operation and maintenance for a very long time. This issue may well be similar to the current situation at OU-2, where EPA is attempting to get the state of Idaho to enter into a Superfund state contract for operation and maintenance of the CTP located at the CIA (EPA 2004b [July 27, 2004]).

Pine Creek. Pine Creek has already experienced considerable cleanup work, particularly by the Bureau of Land Management, and the creek currently supports an adult fishery, including brook trout and native cutthroat trout. The proposed remedial action for this area focuses on habitat rehabilitation and limited removals. The committee commends EPA on efforts to restore fish habitats in upper basin tributaries. Simply removing

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[8]Retention time, also called residence time or detention time, is the time that a volume of water must be in contact with the medium, or material, that removes the metal from the water. In some passive treatment technologies, the material adsorbs the metals from the water; in other technologies, microorganisms generate a product, such as hydrogen sulfide, that reacts with the dissolved metal, converting the metal into a particulate form that is filtered from the water.

[9]A footprint refers to the area required for installation of a treatment plant.

dissolved metals is insufficient to restore fisheries; to be successful, habitat restoration is critical (see Chapter 7).

Remedial Actions Proposed for the Middle Basin (Wallace to Cataldo)

The remedial benchmark for the South Fork Coeur d'Alene River between Wallace and Cataldo is to improve conditions to support a higher fish density (tier 2+ to 3 fishery) (EPA 2002, p. 12-28). EPA's expectation, as stated in the ROD, is that improvements to the South Fork will largely be due to remedial actions planned for Canyon Creek (specifically, the water treatment plant) and Ninemile Creek.

Specific cleanup plans for the South Fork over 30 years call for the removal of about 102,000 cubic yards of floodplain tailings, from what are considered hot spots from Wallace to the eastern side of the box, and some stabilization and bioengineering of the stream channel and banks at a cost of $16 million (EPA 2002, pp. 12-28 to 12-30). However, at this time, this plan is only minimally developed as the locations of the hot spots are not defined, nor are they identified by contaminant analyses, volume measurements, contaminant mobility, or other quantitative factors. Rather, EPA suggests that they will be identified by visual observation made by the Idaho Department of Environmental Quality (EPA 2004b, [July 27, 2004]). EPA dismissed more extensive floodplain sediment removal because the agency believed that this would entail excavation of deeper sediments that would be more difficult to access or that sediments with lower contaminant levels would be removed that would contribute less to achieving the remedial benchmark. The Bureau of Land Management is also planning some floodplain excavation and/or capping activities on lands owned by that agency (EPA 2002, pp. 12-28 to 12-30).

The South Fork Coeur d'Alene River has been the site of some remedial action in the past. The SVNRT conducted floodplain sediment removals at Osburn Flats, and EPA, under the ROD for OU-2, removed about 1.2 million cubic yards of mine waste from the Smelterville Flats area. No evaluations were conducted to quantify the effect of the Osburn Flats removal or the Smelterville Flats removal on water quality (EPA 2004b, [September 17, 2004]). EPA anticipates that the second 5-year review for OU-2, slated for release in September 2005, will address the effectiveness of the Smelterville Flats removals. The agency, however, offers that seeing an impact from this isolated removal may be difficult (EPA 2004b, [July 27, 2004]).

As mentioned previously, EPA concludes that groundwater influxes to the South Fork are the major sources of dissolved metals in this river. However, the committee recognizes that much of the information to implicate specific source areas contributing dissolved metals currently does not exist. As such, it is not possible to link metal loading in surface or groundwater with floodplain sediments or deeper aquifer (or alluvium) sediments, because the metal distribution between these sediments (and their relative contribution to groundwater) has not been characterized. Virtually no leach studies were conducted to assess metal dissolution rates and amounts from particular sediment types, nor has a hydrologic model that describes sources of water and their interactions been developed for the South Fork (or any other area) of the basin. Limited, but illuminating, groundwater studies by Barton (2002) point to a significant contribution of dissolved metals from groundwater influxes near Osburn in the South Fork. Tracer-injection and synoptic sampling techniques (Kimball 1997; Kimball et al. 2002) could prove useful in the middle and upper basin as tools for determining source areas contributing dissolved metals (also see Chapter 4 of this report).

Despite the significant contribution of metals from groundwater influxes, which EPA acknowledges, the agency has explicitly excluded groundwater treatment from the ROD for OU-3. The committee explored EPA's rationale for this decision and found the reasoning ambiguous (see Box 8-4).

BOX 8-4 EPA's Consideration of Groundwater in OU-3

EPA has not clearly stated its rationale for excluding groundwater in its remedial decisions for ecologic protection. The rationale outlined in the ROD can be summarized as follows:

Within the ROD, EPA recognizes that groundwater in the valley-fill aquifers of the upper and middle basin areas are the largest sources of dissolved metals loading to the river and streams (EPA 2002, p. 5.6) and indicates that groundwater will be evaluated later as the Selected Remedy is implemented (EPA 2002, p. 6-4). Conclusions in the ROD derived from the Ecological Risk Assessment (EPA 2002, p. 7-23) are that groundwater was not evaluated because it doesn't come into contact with animals. However, the agency included a groundwater RAO for the protection of ecological receptors: "Prevent discharge of groundwater to surface water at concentrations of cadmium, copper, lead, and zinc that exceed potential surface water quality ARARs" (EPA 2002, p. 8-6). Alternative 3 from the FS is outlined in the ROD and includes a regional active water treatment plant for collected groundwater (EPA 2002, p. 9-9) at Canyon Creek and Mission Flats near Cataldo (EPA 2002, Table 9.2-1). However, groundwater treatment in the South Fork (excluding the box) was eventually dismissed and not included in the Selected Remedy, because EPA concluded that treatment would do less to improve conditions than other actions (EPA 2002, p. 12-29).[a]

[a]EPA hopes that actions taken to date within the box will reduce zinc loading to the South Fork but has not ruled out future RODs, amendments to RODs, or ESDs (explanation of significant differences) if loadings are not reduced (EPA 2002, p. 12-30).

Based on removals that have been conducted up to this point, the committee has not seen evidence that suggests that removals in the basin will actually decrease surface-water concentrations of zinc, although it would be anticipated if the materials were contributing zinc to the surface water. As described above, groundwater is the primary conduit of dissolved zinc to surface water in the upper basin. Therefore, further characterization needs to be conducted to ascertain the materials and source areas contributing zinc to groundwater (which discharges to surface water) or to directly address groundwater if metal loading to the groundwater is determined to stem from subsurface materials too deep or impractical to be removed.

The committee supports the agency's plan to remediate floodplain sediments and stabilize stream banks in the South Fork Coeur d'Alene River to reduce downstream lead loading, lessen contaminated sediment transport downstream, and rehabilitate stream banks to enhance the fishery. Without removing, capping, stabilizing or treating sources, recontamination of downstream remediated sites is inevitable. The committee advocates prioritizing sources so that the most serious contributors to metal contamination are cleaned up first. It is the committee's understanding that the Basin Commission[10] will establish priorities, but the committee believes that, in some cases, this may be difficult, because of lack of data on how much contamination is contributed by source areas (also see discussion in Chapter 4 of this report).

Remedial Actions Proposed for the Lower Basin (Cataldo to Harrison)

Lower basin cleanup actions, summarized in Table 8-10, include those to address the riverbanks, riverbed, and the floodplain. The selected remedy aims to reduce particulate lead loading in the river, reduce toxicity, and reduce human exposure. Some remedial work for protecting human health is ongoing in the lower basin, including the cleanup of several boat ramp and adjacent recreational areas along the Coeur d'Alene River and lateral lakes. Some riverbank stabilization efforts have been conducted principally to minimize erosion of the banks from powerboat wave action. The targets

[10]In 2001, the Idaho Legislature established the Coeur d'Alene Basin Environmental Improvement Project Commission (Basin Commission), which is a governmental authority composed of the federal government, the Coeur d'Alene tribe, the states of Idaho and Washington, and the local counties. The Basin Commission will coordinate environmental response and natural resource restoration throughout the affected area and implement the 2002 ROD approved pursuant to the CERCLA. In August 2003, the Basin Commission issued a 5-year recommended plan outlining the scope and objectives of the proposed work for the years 2004-2008 and the lead planning agencies (Basin Commission 2003). This committee was not asked to consider the structure, development, or effectiveness of the Basin Commission and has not done so in this report.

TABLE 8-10 Summary of Remedial Actions and Benchmarks for Ecologic Protection in the Lower Basin

Area	Benchmark	Actions	Estimated Cost
Lower basin stream banks and beds (riparian and riverine)	• Reduce particulate lead load to river • Reduce soil toxicity for songbirds, small mammals, and riparian plants along 33.4 miles of river by removing 122 acres (30-ft-wide zone) • Reduce human exposure (recreational and subsistence users)	• Do complete removal of contaminated bank wedges from highly erosive areas; where complete removal is not possible, do partial removal possibly followed by capping with clean topsoil • Stabilize banks and revegetate removal areas to protect ecologic receptors and humans • Construct and operate sediment traps at four splay areas after implementing pilot study at one area • Implement periodic removal of riverbed sediments in Dudley reach or other depositional areas identified during remedial design phase	$71 million
Lower basin floodplain	• Wetlands: reduce sediment toxicity and waterfowl mortality; increase feeding areas with lead concentrations less than 530 mg/kg by 1,169 acres and possibly convert 1,500 acres of agricultural land to feeding area • Lakes: reduce sediment toxicity to duck and fishes by remediating 1,859 acres with sediment lead concentrations exceeding 530 mg/kg • Riparian: reduce soil toxicity • Reduce human exposure (recreational and subsistence users)	• Reduce exposure using combination of removals, capping, and soil amendments in areas of high waterfowl use, high lead, road access, and low recontamination potential: Lane Marsh (wetland = 213 acres) Medicine Lake (wetland = 198 acres; lake = 230 acres) Cave Lake (wetland = 190 acres; lake = 746 acres) Bare Marsh (wetland = 165 acres) Thompson Lake (wetland = 300 acres; lake = 256 acres) Thompson Marsh (wetland = 59 acres; lake = 122 acres) Anderson Lake (wetland = 44 acres; lake = 505 acres) • Identify agricultural and other areas with lower levels of lead to provide additional clean feeding areas	$81 million

SOURCE: Adapted from EPA 2002, Table 12.2-1.

cited in Table 8-10 for cleanup under the current ROD were selected by EPA for the following reasons (EPA 2002):

- The selected remedy is what EPA believed could be implemented within an approximate 30-year period and would make progress toward the five CERCLA balancing criteria; protecting human health and the environment, ARAR compliance, effectiveness, implementability, and cost-effectiveness.
- These measures are what EPA thought could achieve the benchmarks (near-term objectives).

Streambank remediation. The grounds EPA gives for cleanup of 33.4 miles of riverbanks (122 acres) along the main stem of the Coeur d'Alene River are to reduce particulate lead loading in the river; reduce soil toxicity for songbirds, small mammals, and riparian plants; and reduce human exposure. The potential exposure to humans during recreation on riverbanks is understood, but the committee questions justifications about wildlife exposure and particulate lead loading in the river for the following reasons:

- There appear to be insufficient data to assess what levels of particulate lead affect songbirds, small mammals, and riparian plants, and what, if any, benefit would be observed when the streambanks are remediated. Although research has been conducted to document exposure to lead in songbirds (for example, Johnson et al. 1999), particularly through ingestion, these results are not nearly conclusive enough to warrant the degree of remediation proposed relevant to ecologic risk in songbirds (see Chapter 7 for further discussion). The benchmarks that have been established for the ecologic receptors are also not quantitative indicators that can be readily monitored. Therefore, it will be very difficult to determine the success or failure of the proposed remedial action. This aspect is discussed in more detail earlier in this chapter.
- It is estimated that only 4% of the lead in the depositional environment of the lower basin resides in the riverbanks (Figure 8-3). Therefore, removal of this amount of lead, compared with the amount that resides in the streambed, will have minimal impact on particulate lead loading in the river. Bookstrom et al. (2004) estimate that riverbank erosion contributes only about 3% of the lead-rich sediment deposited annually on the downstream floodplain and about 3% of that deposited in Lake Coeur d'Alene.

The committee has serious doubts about the long-term efficacy of remediating the streambanks because flooding and resultant recontamination would undo any reductions in soil toxicity or human exposure. During high-flow events, the river overruns its banks, which, in addition to eroding the banks, deposits fresh lead-enriched sediment. Baseline deposition rates on riverbanks are high, averaging 6.9 ± 5.3 centimeters per decade at 3,400 ± 900 parts per million (ppm) of lead (Bookstrom et al. 2004, p. 29).

Some streambank remedial action that is ongoing entails rip-rapping the banks with cobble stones; although this approach appears to stabilize the banks, rip-rap is not a conducive fishery habitat (see Chapter 3, Box 3-1, and Chapter 7). During the design phase, the committee anticipates that EPA will give due consideration to fishery habitat restoration in any actions related to streambank stabilization.

Streambed remediation. The ROD (EPA 2002) calls for removing up to 2.6 million cubic yards of contaminated sediment from the streambed in natural deposition areas such as near Dudley. The rationale for this action is to reduce the movement of lead in surface water. The transport of lead particles by the river is the principal mechanism for transporting lead downstream. Bookstrom et al. (2004) estimate that 70-80% of the particulate lead entering Lake Coeur d'Alene is derived from the riverbed downstream of Cataldo and that 44-48 times more riverbed surface area is exposed to erosive water flows than riverbank surface area. Further, highly contaminated sediments are buried in the lower basin riverbed and they are susceptible to scouring and transport during flood events. The volume, lead concentration, and potential for transport make riverbed sediments a key component of any remedial strategy.

According to what is presented and costed in the ROD, EPA intends to dredge riverbed sediments, dewater the sediments, and treat the water in a settling pond before releasing the dewatering product back to the Coeur d'Alene River. In the ROD, EPA did not consider treating the aqueous dewatering product[11] which can contain high concentrations of zinc. To illustrate, in November 2000, USGS (Balistrieri et al. 2003) collected pore water from sediments at the river's edge at Cataldo. The sediments at this sampling location would be submerged when the Coeur d'Alene River rises during the summer, spring runoff, and flood events. Pore water samples, collected within the sediments at discrete depths ranging from 10 to 25 centimeters showed zinc concentrations ranging from about 13,000 to 36,000 μg/L. Further, oxidation of metal-bearing sediments during their removal and settling can lead to additional metals releases. The release of untreated water from the dredging operation would likely be unacceptable. Treatment of the dewatering product will produce sludge, which must be disposed of in a secure repository.

[11]The aqueous dewatering product is the river water that drains from the sediment after the sediments are removed from the riverbed.

In the riverbed, dredging is a temporary measure because the depositional areas of the river will fill back in with contaminated sediment transported from upstream primary and secondary sources. EPA has considered this and plans to redredge several times throughout the 30-year time frame of the interim ROD. Although dredging and redredging have merit, because sediment conveyed from upstream will be deposited in the same area, the volume of contaminated sediment that will be removed from the streambed is small compared with the total amount of affected sediment deposited in the entirety of the main stem of the Coeur d'Alene River. The committee questions whether removal of such a small amount of sediment will have any measurable effect on lead-enriched sediment transport and deposition downstream and also questions what effect dredging may have on fluvial behavior. Dredging was practiced near Cataldo for some 30 years starting in the 1930s; some lessons surely were learned from this dredging activity. It also needs to be considered that the sediments that refill an area (and are slated for redredging) will likely be lower in concentration than the highly contaminated historical depositions adjacent and elsewhere in the riverbed. As mentioned by Bookstrom et al. (2004), "the dredged river channel probably would re-fill with relatively dilute metal-bearing sediment, transported from the confluence of the North and South Forks, and containing about 2000 ppm of Pb." One thing is for certain—until contaminated sources that exist both upstream and in the lower basin riverbed are removed or otherwise stabilized, particulate lead transport down-river is inevitable.

The ROD states that "other sediment management techniques that may be viable alternatives to [riverbed] sediment removals for reducing particulate lead transport and providing long-term protection will … be evaluated in remedial design" (EPA 2002, p. 12-34).

According to EPA (Dailey 2004) the "ROD thus leaves open the possibility of (for example) capping, rather than dredging, riverbed sediment sources." Capping as an alternative to dredging was further explored by Bookstrom et al. (2004), as was a dredging approach that began at Cataldo and progressed down-river from there. The committee commends EPA for retaining the flexibility to consider alternatives based on new information. All alternatives should be considered on their likelihood of reducing downstream transport of metals and contamination of adjacent wetland areas. The committee also suggests that alternatives be examined to consider: effects on fishery habitat; the potential for release of metals during remedial work; and the effect on fluvial dynamics, particularly the potential for scouring of highly contaminated riverbed sediments. Further studies on the fluvial dynamics of the system will be needed to support these decisions.

Floodplain sediments. Cleanup plans for the wetlands and lateral lakes include removing the top foot of contaminated sediment, which is the sediment ingested by the waterfowl, disposing of this contaminated material in upland or subaqueous repositories, and capping deeper contaminated sediments with clean fill, possibly derived from clean wetlands, marshes, or lateral lakes in the vicinity. EPA also intends to further evaluate phosphate amendments to stabilize lead. To minimize possible recontamination from flood events, levees will be enhanced and floodgates installed.

The interim remedy proposes remediating about 25% (4,528 acres) of wetlands and lateral lakes in the lower basin that waterfowl use during their migration through the basin.[12] RI studies indicate that more than 18,000 acres of waterfowl habitat exceed the adverse-effects level of 530 mg/kg. Because the total contaminated floodplain area in the lower basin is so large, it was recognized that all areas needing long-term cleanup could not be addressed completely in the interim action. Thus, EPA prioritized specific areas. EPA states that these areas were selected based on the following criteria: (1) high use by waterfowl, (2) high levels of lead in sediments, (3) ease of site access, and (4) relatively low potential for recontamination during flood events. However, it is unclear to the committee how areas with low potential for recontamination were selected, as EPA provided to the committee that "adequate data were not available to rigorously delineate areas susceptible to recontamination based on projected average return intervals of flooding events. In particular, the maximum flood level elevations for potential design events and the detailed topography (1-foot contours) required to make such estimates were not available" (EPA 2004b, [June 23, 2004]).

EPA recognizes that available evidence is circumstantial as to whether cleaning up 25% of the contaminated feeding ground will result in a reduction of waterfowl mortality [EPA 2004b (April 6, 2004)]. The Fish and Wildlife Service, with whom the committee met, thought that even this partial cleanup would result in a significant decrease in risk to waterfowl (see discussion above in Ecologic Risks: Rationale for Determining Levels of Remediation). However, the committee is concerned about the potential of recontamination (see below) and the potential that remediated wetlands would be less desirable to waterfowl.[13] Overall, EPA recognizes that a partial effort is not enough to protect migratory birds under the Migratory Bird Treaty Act (EPA 2002).

[12]To be specific, the ROD proposes remediating 1,169 acres of wetland area and 1,859 acres of lake bottom (lake areas less than 6 feet deep) and converting an additional 1,500 acres of land currently used for agricultural purposes to safe waterfowl feeding areas. This 4,528 acres is approximately 25% of the estimated 18,000 acres of wetlands with lead concentrations greater than 530 mg/kg.

[13]Remediated wetlands could potentially be less desirable if vegetation is not reestablished or if that vegetation is not attractive waterfowl habitat. The ROD does not discuss reestablishing wetland habitats conducive to waterfowl following remediation.

Even with large monetary expenditures to remove contaminated sediments, store them in repositories, and construct levees and floodgates, the committee recognizes that severe flood events, which the valley has experienced in the past and will experience again in the future, can undo even the most well-designed and costly remedial actions. It is inevitable that recontamination will occur to some portion or all of what is remediated unless upstream and instream sources are removed and/or stabilized first. This issue is nicely summarized by Bookstrom et al. (2004):

> During episodes of high discharge, Pb-rich sediments will continue to be mobilized from large secondary sources on the bed, banks, and natural levees of the river, and will continue to be transported to the floodplain, and deposited during floods, which occur frequently. This probably will continue for centuries unless major secondary sources are removed or stabilized. It is therefore most important to design, sequence, implement, and maintain remediation in ways that will best limit recontamination.

The committee also cautions that flood control actions, such as enhanced levees, likely will affect river flow and could cause undesirable consequences. This also was considered by Bookstrom et al. (2004). The committee encourages EPA during the remedial design phase to carefully evaluate the consequences of flood control actions.

Also, although soil amendments with phosphate should be considered as a way to sequester lead, the committee cautions that nutrient-based amendments in particular could be problematic because of possible downstream eutrophication effects from excess nutrient runoff.

The committee encourages EPA's efforts to secure agricultural lands, converting them to high-quality feeding grounds. Although it has not been described which lands will be acquired, their level of contamination, or how effective such efforts may be in directing the waterfowl from contaminated areas, reestablishing wetlands in these areas is a laudable effort, particularly if these areas are less susceptible to contamination from flooding.

The other major efforts to protect waterfowl involve removing contaminated sediments from the bed and banks of the lower reach of the Coeur d'Alene River to reduce the likelihood that the cleaned-up areas will become recontaminated as well as to possibly reduce the transport of contaminated sediment through Lake Coeur d'Alene to the Spokane River. This appears to be a largely experimental effort, and EPA has not advanced criteria for evaluating whether it is successful.

According to the agency, the decision to remediate a portion of the wetlands was based on evaluation criteria for Superfund remedial alternatives, key issues associated with implementation of the alternatives, and the input of various stakeholders (states, tribes, federal trustees, and the public) (EPA 2004b [April 6, 2004]). It is unclear how Superfund remedial alternatives were considered, as many criteria (for example, protection of ecologic health, compliance with ARARs, long-term effectiveness, and permanence) likely will not be met. It appears likely that this decision was made primarily on input from various stakeholders. Regardless, decisions about remedial actions proposed in the floodplain of the lower basin need to seriously consider the impact and potential of recontamination as it can quickly undo costly, time-consuming, and resource-intensive remedies.

Lake Coeur d'Alene

Lake Coeur d'Alene is not included in the interim action, because its cleanup is to be addressed via a lake management plan (Coeur d'Alene Basin Restoration Project 1996, 2002; IDEQ 2004) under separate regulatory authorities. Lake Coeur d'Alene will be addressed in a future ROD (EPA 2004a).

There is currently uncertainty about the fate and transport of nutrients and metals after they are released from the lake sediments into the water column (benthic flux) and about the mass balance of metals in the lake on a seasonal basis (see discussion in Chapter 4). Lake Coeur d'Alene is currently the subject of a 3-year, integrated metal-nutrient flux study. Such studies to generate a greater understanding of metals dynamics are needed before a viable lake management plan can be developed and implemented for metals (also see discussion in Chapter 4).

Spokane River

For the Spokane River in the state of Washington, the ROD (EPA 2002) identifies cleanups for a limited number of sediment and soil sites in and adjacent to the Spokane River. These cleanups, estimated to cost between \$4.5 million and \$11 million, are specified for both human health and ecologic risks. Contamination with polychlorinated biphenyls, unrelated to past mining operations, appears to be a more serious issue than metal contamination.

EPA anticipates that implementation of the selected remedy will result in a reduction of dissolved metal loads in the Spokane River of approximately 16% (EPA 2002, p. 12-41). The 16% reduction is anticipated from the selected remedy based on analysis with the probabilistic model. As indicated in the earlier section "Assessing the Probabilistic Model," the committee questions the ability of this model to accurately estimate the effect of remedial actions.

The committee believes that, until upstream source areas are cleaned up, recontamination of remediated areas in and along the Spokane River will be highly probable.

Concluding Thoughts on Remediation of the Coeur d'Alene River Basin

It is apparent to the committee that EPA did not apply either a systems approach (see Chapter 4), which would consider all contaminant sources and all paths of contaminant transport, or a river continuum theory (Chapter 3, Box 3-1) that integrates the entire hydrologic system to the health of the fishery to the design of the selected remedy. Rather, it appears that EPA considered each region of the basin as a separate unit and attempted to develop a remedy for each unit or contaminant problem within that unit. As a result, the remedies are incongruent and do not address the contaminant problems of the basin in a prioritized, systematic manner. One consequence of not using a systems approach that is of particular concern is that recontamination of remediated areas is inevitable.

Particularly troubling is the fact that necessary repositories do not currently exist and potential locations are quite limited in the basin. The siting, design, and public comment stages will take years to complete if a suitable location can be established. Because the ecologic remedies are based primarily on removals of media that require secure storage, any proposed remedies will be delayed for a considerable time.

Another concern of the committee is that EPA primarily used average conditions in designing remedies. For example, average mass loadings were used, despite the fact that metal concentrations at low flows are higher, and, therefore, conditions at low flows are more toxic to aquatic life. At stream flows higher than average, particulate metal concentrations are higher and could result in recontamination of areas that were remediated based on average conditions. The committee believes that these variations may have a significant impact on the effectiveness of the proposed remedies.

Further, it is obvious that floods play a fundamental role in the resuspension and distribution of contaminants in the basin.[14] In particular, the scouring effect of these large floods mobilizes highly contaminated sediments that have been deeply buried. The timing, intensity, and duration of these floods markedly affect the potential for sediment transport. The

[14]"During low-flow periods, total lead loads as low as 30 pounds per day have been measured in the Coeur d'Alene River at Harrison. By contrast, during the 100-year flood event in February 1996, an estimated 1,400,000 pounds of lead were discharged to Coeur d'Alene Lake in a single day" (EPA 2002, p. 5-7).

negative impact of resuspended sediments on human and environmental health coupled with the expense associated with potential remediation and recontamination make it necessary to consider management of the entire watershed to reduce the intensity, frequency, and duration of floods. It is expected that watershed management practices (particularly road density) are linked to water yield and peak flood discharge in the basin (Isaacson 2004). Overall, the basin is experiencing "a more rapid response to runoff producing events [precipitation], with possibly greater peak flows (a flashier hydrograph) than historically occurred . . ." (Idaho Panhandle National Forests 1998, p. 48). To the extent that water yield and flooding can be managed through land-use practices, it is important to include them in the schemes designed to protect human and environmental health.

Given the unrelenting contribution of metal contaminants from sources in the upper and middle basins and the pervasive nature of the deposition of contaminants in the lower basin, it is entirely conceivable that the basin cannot be fully cleaned up by remedial efforts alone. There is even considerable uncertainty about whether remedial objectives set forth in the interim ROD are achievable. However, a number of remedial actions discussed in the ROD and considered in this section of the report are laudable efforts and should be pursed by EPA and others.

What is certain is that, until sources in the upper and middle basins are cleaned up, contaminants will continue to move downstream and mix with the relatively clean but large sediment load from the North Fork Coeur d'Alene River; these collective sediments will deposit in the streambed, stream banks, wetlands, marshes, and lateral lakes of the main stem of the river and eventually settle into Lake Coeur d'Alene.

Natural recovery is a central component of EPA's remedial action plan that predicts outcomes up to 1,000 years in the future. This process will be facilitated if source removal/stabilization in the South Fork and main stem of the Coeur d'Alene River occurs. Deposition rates throughout the lower basin are rapid enough that sediment loads would (if uncontaminated by sediments from the South Fork and resuspension of riverbed sediments in the main stem) expedite natural remediation of the basin.

Clearly, a great deal of new information has been collected by USGS, the Idaho Department of Environmental Quality, the Coeur d'Alene tribe, EPA, and others on sediment dynamics in the South Fork, the North Fork, and the lower basin. Much of this information has become available since the RI was released in 2001 and the ROD was issued in 2002. Many of the remediation plans proposed to mitigate damage to ecologic systems (particularly those involving lead in sediments) have been severely criticized, and recent studies tend to support some of the criticism. The committee believes it is appropriate that EPA develop a holistic methodology to remedial design using a systems approach for sediment dynamics, deposition, and biogeochemistry for the basin as a whole and a river continuum philosophy for habitat restoration that takes into consideration new scientific information.

CONSIDERATION OF NCP CRITERIA AND ADHERENCE OF ACTIONS TO SUPERFUND GUIDANCE

Adherence of Actions to Superfund Guidance

EPA's decision-making process regarding remedial actions in OU-3 of the Coeur d'Alene River basin followed the NCP (40 CFR 300), which is applicable to all Superfund sites. EPA expanded the Superfund site to include lands and waters outside the area surrounding Kellogg addressed in OU-1 and OU-2 after the agency determined the area met the criteria for listing a site on the national priorities list. The agency then proceeded through the RI/FS process of investigating the nature and extent of the contamination (see Chapter 4) and conducting risk assessments (see Chapters 5 and 7). EPA conducted a feasibility study and selected a remedy consistent with the NCP 40 CFR 300 and the CERCLA guidance for conducting an RI/FS (EPA 1988), cost estimating (EPA 2000a), and remedy decision making (EPA 1999). Under this process, EPA developed a range of remedial alternatives, presented in the FS (URS Greiner, Inc. and CH2M Hill 2001a) and described earlier in this chapter. EPA then worked with governmental stakeholders to develop a proposed plan (EPA 2001a) with a preferred alternative, and following a period for public and stakeholder review, developed a selected remedy (EPA 2002).

During this process, the agency has made a substantial effort to work with other federal, state, and local governmental (including tribal) organizations concerned about the human health and ecologic risks in the basin and to inform and receive comments from the concerned public about its findings and actions. A review in March 2004 by the EPA Office of Inspector General Ombudsman (EPA 2004d) found that Region 10 EPA had met and gone beyond requirements for soliciting and including community involvement during the process. Indeed, in the experience of the committee members, the number of cooperating organizations, processes established to provide avenues for citizen participation, and opportunities for the public to obtain information and provide written and verbal input have been substantially greater than what is normal at Superfund sites. Of course, the geographical extent of this site and the fact that it affects two states and two tribes as well as numerous localities necessitates more cooperation and public involvement than a more typical site. Nevertheless, the committee believes that the agency has been unusually open and inclusive in its process.

Although EPA adhered to the typical Superfund process, the Coeur d'Alene River basin is anything but a typical Superfund site, and the nature and extent of the site have created a number of difficulties.

Consideration of National Contingency Plan Criteria

One of the major problems has been the agency's difficulty in identifying remedies that satisfy the nine criteria for evaluating remedies described in Table 8-5 (40 CFR §300.430(e)(9)(iii)). The following sections discuss the extent to which remedial activities address these criteria.

Protecting Public Health and the Environment

The first of the two "threshold criteria" is "protection of human health and the environment." It is expected that cleanup of contaminated soils in yards, recreational facilities, and other sites is expected to be protective of human health, assuming that remediation leads to a decrease in lead intake in children (for further discussion see Chapter 5), and so long as these cleanups are maintained. Similarly, providing alternative sources of drinking water or point-of-use water filters to homes and businesses whose water supply does not meet ARARs is protective of public health.[15] As EPA points out, however, its proposed remedies do not allow for subsistence lifestyles or unlimited recreational use of contaminated areas, and they do not address future use of groundwater (EPA 2002, p. 12-2). Nor has the agency proposed a remedy to address contamination problems in Lake Coeur d'Alene. (EPA 2004b [June 14, 2004]).

The committee is less sanguine about the likelihood of success the proposed remedies will have in protecting the environment (see section Selected Remedy: Geographic Areas, Levels of Remediation, and Remediation Plans). The proposed remedies will not lower the amount of surface-water contamination (particularly from dissolved zinc) to levels specified in water-quality standards to protect native fisheries. Nor is it clear that cleaning up only 25% of the basin's wetlands will provide adequate protection to migratory waterfowl. Nineteen of the migratory bird species in the basin are considered to be at risk from the contamination in the basin (EPA 2002, p. 8-2). EPA recognizes that its proposed remedies may not fully protect human health and the environment and therefore has designated the selected remedies as interim measures, stating in explanation:

[15] One caveat on this conclusion is that the point-of-use water filters will have to be properly maintained if they are to continue to be effective. Indeed, improper maintenance can result in the quality of the output water being worse than the quality of the input water (Health Canada 2005).

> The Selected Remedy is designed to provide prioritized actions towards meeting the statutory requirement of protectiveness of human health and the environment. Accordingly, the Selected Remedy, by its nature, need not be as protective as the final remedy is required to be under the statute. Here, the Selected Remedy is sufficiently protective in the context of its scope, even though it does not, by itself, meet the statutory protectiveness standard that a final remedy would have to meet. (EPA 2002, Declaration, p. 6)

Compliance with ARARs

The second "threshold criterion" is that the remedies have to comply with all federal and state standards or other requirements that are relevant to the proposed cleanup. These standards and requirements are commonly called ARARs.

The ROD lists 35 ARARs and 10 additional guidance, policy, or other materials that EPA has to consider in selecting its final remedies (EPA 2002, pp. 13-7 to 13-16). The agency has sorted them by type as indicated in Table 8-11. The committee has not evaluated the relevance of the ARARs that EPA has identified, nor has it attempted to identify any that the agency has not. The committee does note, however, that (1) the agency did not identify any ARARs or other factors "to be considered" adopted by the tribes or local or regional governmental organizations;[16] (2) the proposed lake management plan may result in the adoption of policies or even regulations that will need to be included in the final list of ARARs; and (3) other environmental quality regulations have been or may be adopted by the state or federal governments before the final remedies are selected (presumably not for several decades at the least), and these too will become ARARs.

With respect to the ARARs that EPA identified, the remedies directed at protecting human health generally appear to satisfy the applicable rules. The only ARAR governing soil contamination was an EPA guidance document recommending a screening level for lead contamination in soil of 400 mg/kg. This recommendation was based on the results of applying the integrated exposure uptake biokinetic model with the "default parameters." In OU-3, a higher screening level was selected with site-specific parameters (see Chapter 6), which is consistent with EPA guidance.

Providing alternative water supplies or point-of-use water filters should be adequate to satisfy drinking water ARARs. Air pollution problems could be caused by soil blowing off construction areas and soil repositories, but wetting these areas, as called for in the remedies, is expected to

[16]However, as indicated below, EPA is evaluating the applicability of water-quality standards adopted by the Coeur d'Alene Tribe.

TABLE 8-11 Number of ARARs, by Category and Jurisdiction, Identified as Pertinent to Bunker Hill Mining and Metallurgical Complex Operable Unit 3

	Jurisdiction			
Category of ARARs	Federal	State	Tribe	Local
Waste management and repository design	2	5		
Air quality	1	3		
Surface-water quality	3	4		
Drinking water quality	1	1		
American Indian concerns and cultural resources protection	4			
Special status species	2	2		
Sensitive environments	3	2		
Other requirements	1	1		
Other policies and guidances to be considered[a]	9	1		
Total (ARARs, to be considered)	17, 9	18, 1	0, 0	0, 0

[a]These are not formal ARARs but rather guidance, policy, or other unpromulgated materials that are to be considered in selecting remedies (EPA 2002, pp. 13-7 to 13-16).

control these problems and satisfy the air pollution ARARs as well as the Idaho Rules for Control of Fugitive Dust.

With respect to achieving those ARARs pertaining to protecting fish and wildlife, however, the interim remedies are likely to be less successful. As the agency states in the ROD, "Although the Selected Remedy is not anticipated to be fully protective of the environment and achieve environmental ARARs, it represents what EPA believes is a significant step toward these goals" (EPA 2002, p. 10-8).

The biggest difficulty is in meeting water-quality standards for dissolved zinc, cadmium, and lead established to protect fish and other aquatic organisms. Currently, the agency argues only that its proposed actions will reduce the time required to achieve such standards, although it will still require hundreds of years to do so. Further, the ROD stated that at least a 50% reduction in lead loading may be needed to attain the AWQC in the Spokane River (EPA 2002, p. 12-110). Yet, it is not clear that actions in the selected remedy are intended to achieve that mark.

It is also unclear whether the interim remedies focused on cleaning up the wetlands and lateral lakes in the lower basin will provide adequate protection for the migratory bird species to satisfy the requirements of the Migratory Bird Treaty Act ARAR.

Several new rules, which probably will qualify as ARARs, have been adopted since the ROD was prepared. One of these is the total maximum daily load (TMDL) restrictions that are being imposed on surface waters not achieving water-quality standards. Proposed TMDLs for dissolved zinc, cadmium, and lead will create particularly serious challenges in the South Fork and main stem of the Coeur d'Alene River during low-flow periods. Because the amount of dissolved zinc entering the river from apparently uncontrollable groundwater flow (see Chapters 3 and 4 and discussion earlier in this chapter) is sufficient by itself to create violations of this standard, the agency will be forced to virtually prohibit any point source discharges of zinc during these periods. Such prohibitions presumably would severely limit the agency's ability to discharge dredging waters back to the river and also would affect the operation of its wastewater treatment facility in Kellogg.

A second new rule is the Idaho groundwater-quality rule, which includes numeric groundwater-quality standards (EPA 2000b, p. A-4). These standards are identical to the federal maximum contaminant levels (MCLs) for drinking water. The rule also lists secondary constituent levels equivalent to the federal secondary MCLs. EPA's initial determination is that the primary standards are "potentially relevant and appropriate" and that the secondary standards are "potentially to be considered" (EPA 2000b, p. A-4).

A third rule for water-quality standards was adopted by the Coeur d'Alene tribe in 2000. The applicable water-quality standards in this rule are virtually equivalent to those adopted by the state of Idaho except that the human health protection criteria are based on higher daily amounts of fish consumption than the EPA and Idaho standards. The agency apparently is still reviewing the tribe's rule. It is not clear what effect these standards would have on the proposed remedies, particularly in that they apply only to the southern portion of Lake Coeur d'Alene.

EPA does not claim to have satisfied all the ARARs with its interim measures, stating that

> The remedial actions selected in this ROD are not intended to fully address contamination within the Basin. Thus, achieving certain water quality standards, such as state and federal water quality standards and criteria and maximum contaminant levels for drinking water, are outside of the scope of the remedial action selected in this ROD and are not applicable or relevant and appropriate at this time. Similarly, special status species protection requirements under the MBTA [Migratory Birds Treaty Act of 1918] and ESA [Endangered Species Act] are only applicable or relevant and appropriate as they apply to the remedial actions included within the scope of the Selected Remedy. (EPA 2002, p. 13-2)

EPA can waive an ARAR for any of three primary reasons (EPA 1996, p. 6). The first is if the agency determines that achieving that ARAR is technically impractical. The second is if the agency determines that the proposed action will "provide a level of performance equivalent to the ARAR, but through an alternative design or method of operation." The third applies only to cleanups financed by EPA's dedicated cleanup fund and "may be invoked when compliance with an ARAR would not provide a balance between the need to provide protection at a site and the need to address other sites."[17] However, the agency has not yet undertaken an effort to waive any ARARs with respect to OU-3 and apparently does not intend to do so until all the interim remedies have been completed (EPA 2002, p. 12-2).

Long-Term Effectiveness and Permanence

The first of the balancing criteria (see Table 8-5) is the preference for permanent solutions. Although EPA states that it "has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site" (EPA 2002, p. 13-19), few of the interim remedies selected by EPA strictly satisfy this criterion. Many have the potential to be undone by floods, which are common in the valley and most selected remedies will require continued monitoring and maintenance to retain their effectiveness. These issues were discussed earlier in this chapter (see "Feasibility and Potential Effectiveness of Remediation Plans").

Reduction of Toxicity, Mobility, and Volume

The interim remedies similarly do not rate well with respect to the second balancing criterion, reduction of toxicity, mobility, or volume through treatment (Table 8-5). EPA seems to recognize this weakness when it states "although the Selected Remedy is not intended to fully address the statutory mandate for permanence and treatment to the maximum extent practicable, the Selected Remedy does utilize treatment, and thus supports that statutory mandate. A comprehensive evaluation for preference for treatment will be conducted in subsequent decision documents" (EPA 2002, p. 13-20). The agency proposes three remedies (hydroxide precipitation with media filtration, permeable reactive barriers, passive treatment pond) or studies that would involve treatment (EPA 2002, Table 9.2-2). However, most of the proposed remedies do not involve treatment, although EPA is considering a proposal to use soil amendments to reduce the bioavailability

[17]These are the primary reasons for waiving ARARs, although the CERCLA legislation and the NCP list three others as well.

of lead contained in some of the sediments in the lower basin (EPA 2002, p. 12-111).

The remedies do include some provisions that will reduce the mobility of the contaminants. These include excavating contaminated sediments from the river channel and floodplain areas, placing the excavated materials in repositories with erosion-resistant caps, and stabilizing sources of contaminated sediments in situ (for instance, by the use of soil amendments). Some proposals such as installing grout curtains to contain and treat groundwater (for example, the efforts on Ninemile Creek at the Success Mine and Mill Site in Ninemile Creek) (Calabretta et al. 2004) would also serve to reduce the mobility of the contaminants, but the practicability and effectiveness of such approaches is highly uncertain. Placing erosion-resistant caps on repositories as well as removing contaminants from potential inundation by floodwaters may reduce the effective mobility of these materials.

Virtually nothing has been proposed to reduce the volume of contamination.

Short-Term Effectiveness

The remedies selected for protecting human health are expected to rate relatively high with respect to short-term effectiveness, assuming that yard remediations will limit lead absorption indoors (see Chapter 5 for discussion).

The short-term effectiveness of the remedies focused on protecting fish and wildlife is less certain (see section Selected Remedy: Geographic Areas, Levels of Remediation, and Remediation Plans in this chapter). The effectiveness of the upper basin remedies is uncertain. As mentioned, it has not been demonstrated that removing selected floodplain materials would decrease inputs of dissolved zinc. Implementing some of the lower basin remedies will substantially disrupt the wildlife habitat being "remedied," giving them a negative effectiveness in the very short term. The proposals to establish new wetland habitat on existing farm land will not suffer from these problems, but their short-term effectiveness will depend on whether and how quickly viable wetland communities can be established on these lands and on the success of these efforts in attracting waterfowl away from the more contaminated areas.

Implementability

Again, a distinction has to be made between those remedies focused on protecting human health and those focused on protecting environmental health. The former have already been demonstrated in the box and at other Superfund sites to be relatively easily implemented, although, as voiced at the public comment session at the committee's meeting in Wallace, Idaho, some land owners in the Coeur d'Alene River basin have exhibited a resistance to having their yards remediated.

As discussed earlier in this chapter, the implementability of some of the remedies proposed for environmental protection is less certain, and the agency has been frank in indicating that some of the proposals need to be tested through bench-scale and pilot-scale studies. One example is the effort to control the flow of zinc-rich groundwater by installing grout curtains. The effort to accomplish this in Ninemile Creek has had limited success because of the very low interception rate of groundwater (see Chapter 4).

The proposal to dredge the riverbed near Dudley is similarly uncertain, although in this case the question is not whether the dredging can be done—it has been done at this site in the past and presents no particular engineering problems. The question is how effective such an effort will be in reducing the flow of contaminated materials downstream, how long the effectiveness will last, and whether the dredging and disposal of dredge spoils can be done in such a manner as to avoid creating serious short-term environmental problems.

Another question about implementability is whether the agency will be able to find adequate repositories for all the contaminated soils it proposes to remove and sources for all the "clean" fill it proposes to use. The process of excavating contaminated soils and disposing of them in a secure landfill has been demonstrated at many Superfund sites. However, the Coeur d'Alene River basin presents special challenges because of the volume of materials proposed for excavation[18] and limited areas with geographic characteristics appropriate for siting a repository. The FS was undertaken with the assumption that such sites could be found, but none has been identified except the repository being used for the relatively limited removals involved in the yard cleanups. Similarly, the geology of the basin provides limited sources of clean fill without seriously disrupting human and natural environments.

Cost

The law establishing Superfund (CERCLA) requires that the selected remedy be cost-effective (40 CFR 300.430(f)(1)(ii)(D)). In its strictest sense, the term cost-effective means that, if alternative remedies will provide the

[18]For example, the proposal to dredge the riverbed near Dudley is expected to produce 1.3 million cubic yards of excavated material (2.6 million cubic yards if the project is "demonstrated to be compliant with ARARs and cost-effective") (EPA 2002, p. 14-1). The removal of the Coeur d'Alene River banks is expected to produce approximately 400,000 cubic yards. In comparison, the approximately 256 acre CIA contains 24.2 million cubic yards of material (URS Greiner, Inc. and CH2M Hill 2001h, Appendix J, Table A-8).

same protection to human health and the environment, EPA must select the least expensive of these alternatives. However, the alternatives identified in the FS provide different degrees of protection. Thus, the cost-effectiveness criterion, as strictly defined, is not relevant.

EPA, however, uses a somewhat looser definition of cost-effectiveness, stating that "a remedial alternative is cost effective if its 'costs are proportional to its overall effectiveness'" (40 CFR 300.430(f)(1)(ii)(D)). The agency explains that the cost criterion enters into the remedy selection process in two ways:

1. A remedial alternative is cost effective if its 'costs are proportional to its overall effectiveness' (40 CFR 300.430(f)(1)(ii)(D)). Overall effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing criteria: long-term effectiveness and permanence; reduction in toxicity, mobility and volume (TMV) through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to determine whether the remedy is cost-effective (*id.*) (EPA 1996, p. 5).

2. Cost is evaluated along with the other balancing criteria in determining which option represents the practicable extent to which permanent solutions and treatment or resource recovery technologies can be used at the site. This balancing emphasizes two of the five criteria (long-term effectiveness and permanence, and reduction of TMV through treatment) (40 CFR 300.430(f)(1)(ii)(E)). However, in practice, decisions typically will turn on the criteria that distinguish the different cleanup options most. The expectations anticipate some of the likely tradeoffs in several common situations, although site-specific factors will always play a role (EPA 1996, p. 5).

In essence, the agency looks at the tradeoff between the amount of protection provided by the alternative remedies and the costs of these remedies, and then makes a judgment about which of the alternatives appears to provide adequate protection at a reasonable cost.

In the Coeur d'Alene River basin, however, some of these judgments are very difficult, for—at least in the case of environmental protection—none of the alternatives considered is expected to provide the amount of protection required by law. The agency is not particularly clear about how it made these judgments but asserts that "the Selected Remedy achieves a significant reduction in residual risk relative to its cost. It would be cost effective as its costs are proportional to its overall effectiveness" (EPA 2002, p. 10-9). High costs were a consideration in EPA's decision not to select the large-scale cleanup that would provide the amount of protection required by law (EPA 2002, p. 10-3). Instead, EPA crafted the less-ambitious selected remedy to achieve a significant reduction in residual risk.

In addition to these issues, questions can be raised about the cost estimates themselves. Although the cost estimates for yard remediation appear to be accurate,[19] cost estimates for excavating and disposing of large amounts of material in the lower basin, for instance, are very uncertain because EPA has not identified any repositories for these materials, and, therefore, transport distances, methods, and operating costs are not known. The uncertainty about the costs associated with some of the more experimental remedies is even greater.[20]

Another question is whether all the costs of the proposed remedies have been considered. For example, EPA informed the committee that its dredging cost estimates included the cost of settling ponds (located either on a barge or on the land), but no additional treatment for the discharges from such ponds (EPA 2004b, [July 27, 2004]). As discussed earlier, this discharge may well require expensive treatment to remove dissolved metals before being discharged back to the river. In addition, it is highly likely that some of the areas that the agency proposes to clean up will be recontaminated by flood deposited sediments, and it is not clear that the agency has adequately taken account of the cost of redoing the remedies in these areas. The cost estimates should reflect the likelihood of a cleanup action being vulnerable to recontamination by flooding.

As a result, EPA's statement that this "order-of-magnitude engineering cost estimate" is expected "to be within +50 to –30% of the actual project cost" (EPA 2002, p. 12-37) may, for a number of reasons, be overly optimistic. However, it is not clear that improved cost estimates would affect the relative attractiveness of the different alternatives identified in the FS, although substantially higher costs might cause EPA to reduce its expectations of what it can afford to do in the valley.

Perhaps more problematic are the externalities or indirect costs associated with many of the proposed remedial actions. For instance, the proposed remedies involve excavating and transporting millions of cubic yards of materials. One commenter estimated that 1,170,000 truck trips would be required to implement Alternative 3 identified in the FS and that, assuming an average distance of 20 miles per trip, the total distance driven by these trucks would exceed 23 million miles (ASARCO 2001; URS Greiner and CH2M Hill 2001a, Appendix I; Temkin 2004).

Although the remedy selected in the ROD would involve less excavation and material movement than Alternative 3 (and therefore fewer truck

[19]Costs for the actual cleanup work conducted under contract in the box are very close to the original estimate and could actually end up lower than estimated (GAO 2001).

[20]The committee also found that there were a number of errors and inconsistencies in the cost estimates for at least one remedial action (removal of riverbed sediments in the lower basin around Dudley) it examined (EPA 2004b [September 10, 2004]).

miles traveled), the impact of such traffic could impose significant costs, which are not included in the cost estimates, on the valley communities.[21] Examples of such costs include wear and tear on roads and bridges, increased maintenance costs and inconvenience for other vehicles using these roads, vehicle accidents,[22] air pollution, and noise.

Other components of the remedies also could create such external costs. Such externalities, of course, are likely to be associated with any Superfund cleanup or other large construction project. What makes them particularly significant in the case of the Coeur d'Alene project is their magnitude and duration, as well as the topography of the valley.

Another external cost, of a different nature, that concerned several people making presentations to the committee, was the possible impact that designating the valley as a Superfund site would have on its economic prospects. As indicated in Chapters 2 and 3, the economy of the valley has suffered since most of its mines and the Bunker Hill smelter closed. Some residents and potential developers hope that the natural beauty and historical significance of the valley will make it attractive for recreational and second-home developments and fear that the Superfund designation may severely limit this potential.

It is impossible to assess the significance of this potential effect without substantial uncertainty, and there is little that the agency can do to avoid it even if it is significant. It is perhaps unfortunate in this regard that some statements describing this site refer to the entire 1,500-square-mile project area, whereas the contaminated area designated as OU-3 is very much more limited.

There is also some anecdotal evidence that the impact may not be as serious as some valley residents fear. Indeed, recreational developments are being built in Kellogg inside the box, which was initially the most-contaminated area in the basin (Kramer 2004). Perhaps the developer rationalized that the cleanup conducted under OU-1 and OU-2 has addressed

[21]EPA also indicates in the ROD that it thinks that dredged material may be transferred by pipeline.

[22]The average accident rate for heavy trucks is approximately 50 per 100 million miles of travel. The comments referenced above estimated that, using national average rates, the amount of travel required to implement Alternative 3 would result in more than fifteen injuries and, more likely than not, at least one fatality. Most of these would occur to other drivers and pedestrians, not the truck operators. Although the selected remedy would involve less transportation than Alternative 3, the accident rate (in terms of the number of accidents per million miles driven) could well be higher given the narrow, twisting roads that are typical in the valley. This issue is addressed briefly in the FS in the evaluation of the short-term effectiveness of the ecologic alternatives (URS Greiner, Inc. and CH2M Hill. 2001a, Part 3, p. 6-49). However, the agency appears to consider it to be something that can be controlled with adequate safety measures.

the health risks and has limited the liability he might face compared with building in a part of the valley where cleanup has not occurred.

In such ways, the cleanup might generate some external benefits as well as external costs. Other obvious examples are the long-term employment opportunities for valley residents that such a massive project will create and the economic stimulus that valley merchants will likely experience as a result of all this activity. The valley may even end up with better roads as a result of the improvements that will likely be needed to handle the projected truck traffic.

Such costs and benefits, of course, are very difficult to quantify in monetary terms. However, this does not make them any less significant. In projects as large as this, they are sufficiently significant that the committee concludes they should be explicitly considered when comparing alternative approaches and remedial actions even if they are not included in the quantitative cost estimates.

State Acceptance

As indicated earlier in this chapter, EPA has apparently made substantial efforts to coordinate its plans and proposals with other governmental organizations. As a result, it has received the required concurrence of the states involved.

Community Acceptance

From the extensive comments made to the committee during its public sessions, the agency clearly has been less successful in obtaining community acceptance. Although the positions taken were not unanimous, many residents of the upper basin generally opposed the project, wanted the site delisted, and hoped never to see an EPA employee or EPA contractor again, whereas residents living downstream tended to argue that the agency was not doing enough and that the project would leave many potential human health and environmental problems. Indeed, even those committee members who have had substantial experience with Superfund projects found an exceptionally high level of contentiousness in the Coeur d'Alene River basin in spite of the efforts the agency has made to communicate with residents. Some of the contentiousness could be due to the high degree of uncertainty in EPA's ability to develop quantitative estimates of time, costs, and reduction in risk. The committee finds this situation very unfortunate but was not asked to and did not attempt to recommend how it can be substantially improved.

CONCLUSIONS AND RECOMMENDATIONS

This section provides the committee's conclusions and recommendations regarding EPA's scientific and technical practices in establishing Superfund site remedial objectives and approaches in the Coeur d'Alene River basin.

Conclusion 1

EPA has followed the procedures and requirements as understood by the committee set forth in the legislation establishing the Superfund program and in the NCP for determining the nature and extent of contamination at National Priorities List sites and for selecting remedies to reduce the risks to human health and the environment resulting from this contamination.

The agency has gone to great lengths to provide the public with information about its activities and to provide opportunities for the public to comment on its plans, findings, and decisions.

Conclusion 2

EPA has adequately characterized the feasibility of alternative actions it could take to protect human health in the basin, and the selected remedies should provide adequate protection to the most significant risks. The effectiveness of the remedial actions for human health protection, where they have occurred, needs to be further evaluated.

The agency has implemented similar measures in OU-1 and OU-2 and at other sites. However, EPA has not, as it points out, addressed human health risks that might be associated with subsistence living, unlimited recreational use of contaminated areas, or future use of groundwater. It also has not proposed a remedy to address contamination problems in Lake Coeur d'Alene, although no significant human health risks resulting from this contamination had been identified at the time the ROD was released.

Conclusion 3

EPA has not adequately characterized the feasibility and effectiveness of actions to protect fish and wildlife resources in the basin.

In several cases, substantially more investigation and experimentation are needed to determine whether the selected remedies are effective and feasible. Even if they prove to be so, it is highly unlikely that they will sufficiently reduce the risks resulting from the basin's contamination to meet Superfund requirements to protect the environment and satisfy ARARs. The agency recognizes this weakness and therefore has designated its proposals "interim remedies." The agency has begun some of the investigation and experimentation needed, and the committee supports these efforts.

Recommendation

EPA should support the substantial additional characterization that will be required to determine whether the interim remedies proposed are feasible and to what extent they will effectively reduce environmental risks. EPA and the state of Idaho also should investigate the feasibility of developing biologically based water-quality criteria that could provide alternatives to concentration-based ARARs. In addition, a strategy is needed for evaluating the performance and efficiency of the selected remedies.

Conclusion 4

The lack of repositories for contaminated soils and sediments is particularly problematic and is a primary concern to the committee regarding the feasibility and implementability of the proposed remedial actions in the basin.

The selected remedy proposes removing large quantities of materials that, at present, have no location for disposal. The siting, design, and construction of repositories will take a long time, if these actions are even possible, especially considering the geography of the basin and the contentious political climate.

Conclusion 5

None of the remedies proposed for cleanup and risk management in the Coeur d'Alene River basin is permanent.

Remediated sites are likely to suffer from recontamination from sediment carried by the frequent floods in the basin. These floods can also erode protective caps covering contaminated areas, thereby eliminating the protection that the caps provide. The need for lifetime maintenance of remedies selected for management of risks to human health has already been demonstrated in the box where, in 1997, floods recontaminated remediated areas. The state of Idaho and the Panhandle Health District have established a process for monitoring the integrity of the human health protection measures and apparently were successful in re-establishing the human health protection measures after the flooding. However, the process will have to remain in place essentially in perpetuity to respond to problems created by future floods and other events that compromise the integrity of remedies.

Recommendation

A plan should be developed to create appropriate institutions and funding to maintain selected remedies through time. Such maintenance will be required for hundreds of years.

Conclusion 6

The Coeur d'Alene River basin is a system where floods play a fundamental role in the resuspension and distribution of contaminants. The timing, intensity, and duration of these floods markedly affect the potential for sediment transport.

The negative impact of resuspended sediments on human and environmental health coupled with the expense associated with potential remediation and recontamination make it necessary to consider management of the entire watershed to reduce the intensity, frequency, and duration of floods, as it is expected that watershed management practices (particularly canopy removal in forests and road building) are linked to water yield in the basin.

Recommendation

To the extent that water yield and flooding can be managed through land-use practices, it is important to include these in the schemes designed to protect human and environmental health.

Conclusion 7

Ultimately the contamination problems in the Coeur d'Alene River basin, Lake Coeur d'Alene, and the Spokane River will be solved only when the contaminated sediments in the river basin have been removed or stabilized.

Efforts to remove contaminated sediments in the lower basin are likely to be of limited value until the problems of sediment transport from the upper and middle basins have been adequately addressed. Even when sediments have been physically stabilized, as they have in the embankment of Interstate 90 and the former Union Pacific Railroad bed, groundwater seepage through these materials still may contain high levels of dissolved metals and may need to be collected and treated.

Recommendation

The committee recognizes that it is not feasible to remove all the sediments but strongly supports the proposed remedies that call for the removal or stabilization of potentially mobile sediments in the upper and middle basin and urges EPA to explore additional opportunities for such actions.

Conclusion 8

Recontamination is a major issue relating to the protection of waterfowl and their habitat, and the committee has significant concerns about the likely effectiveness and long-term viability of many of the remedies proposed to reduce waterfowl mortality. The committee supports measures such as restoring wetlands on agricultural lands in the lower basin and upgrading the quality of the habitat in existing wetland areas that have the least likelihood of being recontaminated.

Many of the wetland and lacustrine areas in the lower basin are likely to be recontaminated by the first major flood that occurs after their remediation, and the likely effectiveness of some of the measures proposed to reduce such recontamination is very uncertain. Recontamination is less problematic in areas such as the lower basin agricultural lands that formerly were wetlands and some wetlands and lacustrine areas historically protected from extensive flooding. Increasing the available area of high-quality waterfowl habitat may reduce waterfowl mortality; however, these reductions can occur only if the availability of the restored or enhanced habitat substantially reduces the use of more heavily contaminated areas by waterfowl.

Recommendation

The committee recommends that EPA proceed in implementing those remedies that are most likely to be successful and durable, particularly regarding recontamination of remediated areas. It will be essential to monitor the success of these efforts both in attracting waterfowl to the wetlands that have been remediated and in reducing waterfowl mortality.

Conclusion 9

The riverbed downstream of Cataldo represents the largest repository of lead-contaminated sediments susceptible to transport during severe flood events. The mobilization of these deposits results in further contamination of adjacent riverbanks and wetlands as well as downstream transport into Lake Coeur d'Alene and eastern Washington.

The riverbeds hold most of the lead in the lower basin. These sediments contain high concentrations of lead and present a large surface area susceptible to the erosive and scouring effects of floods. Monitoring has demonstrated that, during flood events, lead concentrations increase in the river downstream of Cataldo and that riverbed sediments in the lower basin are redeposited on the banks and adjacent wetlands. It is estimated that the riverbed of the lower basin is the source of 70-80% of the particulate lead entering Lake Coeur d'Alene. Without corrective measures, it is expected that these sediments will continue to move downstream.

Recommendation

Priority should be given to remedial measures that address the largest potentially mobile sources of lead-contaminated sediments. High priority should be given to understanding the process of flood scouring of the channel below Cataldo. Remedial designs to stabilize or remove this source will need to consider the impacts to fluvial behavior from dredging or riverbed-armoring operations, potential downstream migration of suspended sediments from potential dredging operations, and elevated zinc in settling pond effluents in potential dredging operations. If dredging is selected, riverbed recontamination will be another important consideration, especially until upstream areas are removed or stabilized, as continuing deposition of contaminated sediments (albeit at a much lower concentration) is ongoing (see Conclusion 7).

Conclusion 10

Riverbanks possess a relatively small proportion of the lead that is available for transport in the system; they have a high likelihood for recontamination; and there is insufficient information available to assess the risks that existing riverbank materials present to environmental receptors.

Riverbank remediation is intended to reduce particulate lead loading in the river and soil toxicity to songbirds, small mammals, and riparian plants. The rationale for excavating the riverbanks is questionable because only a small percent of the lead in the depositional environment of the lower basin resides in the riverbanks, and, compared with the riverbed, a small surface area is exposed to surface-water flows. Further, limited evidence exists linking the presence of lead-contaminated riverbanks to exposure and impacts to songbirds and small mammals. In addition, remediated riverbanks will be highly susceptible to recontamination by the deposition of contaminated sediments derived from the riverbed or upstream sources during flood events.

Recommendation

EPA should not give priority to the less-certain proposed remedies until it can better demonstrate the likely effectiveness of these efforts.

Conclusion 11

The likely effectiveness of the interim remedies EPA has proposed to reduce risks to aquatic life is uncertain.

The threat to aquatic life results primarily from the influx of groundwater containing high levels of dissolved metals, particularly zinc during the late summer low-flow season. A substantial portion (modeled at 41%) of the dissolved zinc in the lower basin results from groundwater seepage through the box area, but EPA has excluded this area from consideration in OU-3. It appears unlikely that the agency will be able to achieve water-quality standards downstream from the box without reducing the amount of zinc coming from this source. Based on removals that have been conducted up to this point, the committee has not seen evidence suggesting that removals in the basin have decreased surface-water concentrations of zinc, although that would be anticipated if the materials were contributing zinc to the surface water. The agency has proposed some innovative approaches to reduce zinc loadings from the upper basin streams, such as Canyon Creek and Ninemile Creek. Although the committee endorses continued experimentation with such techniques, it notes that they have had limited success, and these approaches are not likely to be effective where large volumes of water require treatment. Because passive systems are probably inappropriate for treatment of large volumes where very large areas are not available to provide for long detention times (for example, in Canyon Creek), the agency will have to explore alternative approaches if it is to reduce zinc loadings from these larger volume sources. The committee also questions the wisdom of using phosphate as a sequestering agent, because this may result in eutrophication problems in Lake Coeur d'Alene.

Recommendation

Characterization needs to be conducted to locate the specific sources contributing zinc to groundwater (which subsequently discharges to surface water) and set priorities for their remediation. Groundwater should be addressed directly if loading to the groundwater is determined to stem from subsurface materials too deep or impractical to be removed. Further, EPA should continue to support research on and demonstration of low-cost innovative groundwater-treatment systems. In particular, the agency should place a high priority on identifying possible methods of reducing metal loading in groundwater from the box and highly affected tributaries.

Conclusion 12

EPA proposes using adaptive management in implementing interim ecologic-protection remedies; however, EPA's approach to remediation does not include all the elements needed for an effective adaptive management approach.

Adaptive management is not synonymous with trial and error. Rather, adaptive management is a multistep, interactive process for defining and implementing management policies for environmental resources under conditions of high uncertainty concerning the outcome of management actions. Development of explicit remediation objectives and performance benchmarks, together with a monitoring program to measure progress toward the objectives, is critical to achieving maximum benefits from the adaptive approach. Many of the performance benchmarks and monitoring indicators described in the ROD and the BEMP, especially those that relate to terrestrial biota and habitats, are insufficiently specific to support a truly adaptive approach.

Recommendation

EPA should improve its use of the adaptive management approach by establishing unambiguous links between management objectives, management options, performance benchmarks, and quantitative monitoring indicators for all the habitats and biological communities addressed in the ROD.

Conclusion 13

The reliability of the model for predicting postremediation concentrations of dissolved zinc (probabilistic model) is highly questionable because it appears to be based on an untested hypothesis that is not supported by theoretical or experimental evidence. Furthermore, the time variation contained within the model is incorrect.

The probabilistic model is used to estimate relative loading potentials based on estimated total volume of contaminated material, estimated concentration of available zinc, and estimated effectiveness of various remediation methodologies in reducing metal loading. There are no leach test data from sediments or tailings that would provide rates and quantities of metal release over time, allowing extrapolation of relative loading potential. There are no measurements of groundwater-quality upgradient or downgradient of the various source types used in developing the model, and there is no evidence of the effectiveness of proposed remediation methodologies in reducing relative loading potential. The probabilistic model has not been calibrated in a rigorous sense other than the calibration that is inherent in the model's use of statistical results from historic monitoring data as the preremediation condition.

Recommendation

EPA should support the development of a predictive tool based on sound scientific principles and supported by site-specific information on leaching potential, groundwater movement, and other such factors to allow them to accurately assess the likely effectiveness of remedial actions on dissolved metal loadings from various sources along the river.

Conclusion 14

The transport of contaminated sediment through the basin and the rest of the project area is a key factor in determining the likely effectiveness and durability of proposed remedies.

EPA has not developed a sediment-transport model for the basin that would allow these factors to be evaluated. USGS has collected and is collecting some very useful information about flood flows and sediment transport in the basin that would support the development of such a model. Such a tool would be very useful in assessing the likely long-term effectiveness of proposed remedies focusing on reducing the risks resulting from lead-contaminated sediments.

Recommendation

EPA should develop a quantitative model using a systems approach for sediment dynamics, deposition, and geochemistry for the basin as a whole and should use the results of this model in designing and establishing priorities for proposed remedies.

Conclusion 15

Implementing remedies at a Superfund project as large and complicated as the Coeur d'Alene River basin can generate significant indirect costs and environmental impacts that the agency has not adequately considered in evaluating the alternative remedies.

The indirect costs include, among other items, likely accidents, wear and tear on basin roads, traffic congestion, and other costs associated with the large volume of traffic that could be required to implement some of the remedies. Potential environmental impacts include, for example, silt mobilized by dredging and excavation in aquatic environments, reduction in the quality of habitat for aquatic organisms, and air emissions from the truck traffic and construction machinery. The committee also cautions that flood-control action, such as enhanced levees, can affect river flow and cause undesirable consequences. The committee encourages EPA during the remedial design phase to carefully evaluate the consequences of flood-control actions.

Recommendation

In establishing priorities for designing and implementing remedial actions, EPA should consider the potential indirect costs and environmental impacts of the remedies being considered.

Conclusion 16

The large uncertainties in the present understanding of the mechanisms of release of metals and nutrients from Lake Coeur d'Alene sediments and their transport and fate after release will limit development of an effective lake management plan.

Lake Coeur d'Alene is currently the subject of a 3-year, integrated metal-nutrient flux study. Such studies to generate a greater understanding of metals dynamics are unquestionably needed before a viable lake management plan can be developed and implemented to limit the effects of metals loading to the lake on environmental and human health risks—including those associated with the Spokane River.

Recommendation

Comprehensive studies of Lake Coeur d'Alene should be given a high priority to support development of an effective lake management plan.

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